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Efficiency of Internal logistics –
Restructuring of storage and production area

A bachelor thesis within the program Economics and Manufacturing Technology

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CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2017

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Introductory remark
The thesis work is performed within the bachelor program of Economics and Manufacturing Technology at Chalmers University of Technology. The study includes 15 education credits and has been performed during spring 2017. The thesis work has been performed at a distribution company located in Gothenburg but the case studies have been performed in their factory located in eastern Europe.

The company has made the decision of being anonymous and we will therefor not be mentioning the names of the company or the employees. All the figures in the report are schematic because of the anonymity. Due to confidentiality, the values in appendix contains fictional values.

We would like to thank our supervisor at the company for giving us a good insight of the company and its processes in the warehouse. Despite his other projects within his work he always took the time to answer our questions. We had great discussions throughout the study and he challenged us to think in other directions which helped our study forward.

All the employees and the managers in the factory was very helpful during our visit, and we would therefor like to thank all of them.

Our supervisor at Chalmers has been a big support in the theoretical area as well as in discussions about our solution proposals. She always took time to meet us and led us forward during the project when we had problems with knowing how to reach the next step.

Abstract

A study has been performed at a distribution company on one of their productions placed in eastern Europe. The company sells extruded aluminum beams that either are sold as pieces or could be cut after customer demand. The study's focus is on the handling of the beams that are cut but the beams sold as pieces without cutting are an influencing factor and because of that they need to be taken in consideration. The company charges the customer for the actual beam and the order specific modifications. The process of modifying the beams are only 10% of the total handling time and therefor a lot of work is performed without financial gain. Because of this the study have investigated the possibilities of improving the internal logistics connected to the cutting process. The study includes literature study and empirical study that have been performed during a four day visit in the factory.

Analyzes of the internal logistics are performed in order to create a current state description. The current state is used to identify bottlenecks and define the problems with current state. To concretize the problem two main questions are formulated which are used to solve the problem. The questions concern the storage of beams and the layout of the cutting area. On the grounds of the empirical study, calculations and theory several proposals on how to store the beams and how the layout could be designed and created and presented in the report. The final proposal of a new stock allocation reduces handling time up 60%. This stock solution is recommended in combination with a new layout of the productions area that will facilitate and reduce the movement by the production area.

Keywords: *internal logistics, efficiency, storage, layout.*

Contents

1 Introduction

This chapter is intended to provide an initial description of the study. The study's scope will be presented in the background followed by objectives, delimitations and purpose of the study.

1.1 Background

The study has been performed at a company during the period between the end of March until June. The company has chosen to be anonymous and will therefor be called Beam Producer AB and the company throughout the study.

Beam Producer AB sells extruded aluminum beams. Their assortment includes different types of beams with the lengths three and six meters that is partly sold in pieces. The company also makes it possible to order the beams in millimeters that are cut after order specific customer demand. To be able to separate the beams sold in pieces and the ones sold in millimeter the customer adapted beams are placed under a different item number in the system where the unit is converted from pieces to millimeters. The company sells about 200 different kinds of millimeter beams each year.

The company's business concept is to deliver to customer as soon as possible after the order is placed. The order process is ongoing throughout the day and the planning is made reactively after registration of customer orders. The team leader then converts the orders to picking lists which is the base for the work that the operators will do during the current day. The company does not use the methodology of grouping the orders to combine a working procedure to make the production process as efficient as possible. In current situation, it is not possible because the order receiving happens reactively and they do not have a system that manage to create this type of list. Since the material is cut according to customer orders there are scrap material that in some cases are to short to be reused and therefore needs to be thrown away.

The company have a storage area and the stored material is placed in racks that are up to 8 meters high. When the material is about to be cut it is picked from the beam racks with a customized forklift from the storage area. The material is then driven to the cutting area and the beams are thereafter cut after customer order. Remaining material is transported back to the storage area and the prepared order is either transported to the packaging area, to the manufacturing area or in some cases to the company's own production which is placed under the same roof. All transportation within the factory is executed by forklifts, but light weight material is often picked by hand by the operators. Statistics on sales from earlier years is used to make a prediction model for future sales that is used to plan the assortment and which quantities to store in the warehouse. However, the customer behavior can not be predicted, neither the kind of beam or number of millimeters that the customer will order at a specific time.

Earlier time studies made by the company has shown that the actual cutting time is only 10% of the total handling time. In the company's cost model it is assumed that both beams in pieces and millimeters has the same cost per millimeter material. The company have a pricing model that compensates the company for the cuts, but at the same time is attractive for the customers. With its service commitment, the company wishes to satisfy its internal and external customers as well as their own sale companies. If the needs from these actors are not satisfied there is a risk of them investing in their own cutting machines locally. If these actors would invest in their own cutting machines, Beam Producer AB would have additional cutting machines globally which would only lead to extra expenses for the company. This has resulted in the company only compensating for the cutting time and not the total handling time.

The company has the opportunity to invest in a storage machine for the beams where the magazines are refilled manually but automatically distributes the right beam at the right time. The company do not have the financial opportunity to invest in a machine that has space for the whole storage but only for a part of the storage.

1.2 Objectives

Beam Producer AB wants an investigation on the possibilities of improving their internal logistics to reduce the handling time and thereby change the relationship between the efficient processing time and the handling time. So what the company requests is a more efficient solution for the flow connected to the cutting process.

To meet the objectives, the handling of the problems have been concretized to two main questions that are presented below.

- How could the storage be organized to be as efficient as possible based on the existing resources?
- How could the layout of the cutting area be designed to facilitate the processes?

A suggestion on how to improve the internal logistics will be presented, including proposals for a new storage allocation and handling, where some concerns a new placement of beams. A proposal for a new layout of the production area will be performed and presented as a basis for the improvement suggestions.

1.3 Delimitations

The project is limited to only the cutting process and handling time associated to the cutting. No regard is taken to the steps before the beams are picked from the storage or after the beams are cut and goes further down the product chain. The study is concentrated to the handling of the millimeter beams but the beams sold as pieces without cutting are factors that affect the millimeter beams and therefore they need to be a part of the study. The project's focus is to make the handling time more efficient, therefore the time of the actual cut of the beam is not handled.

Beam Producer AB have a seasonal variation, trending is that the sales decline during the first quarter and increases during the third and forth quarter. Because of the seasonal variations, data from a specific month would give a incorrect value that would not correspond with the sales for an entire year. Due to that, data from the whole year of 2016 was reviewed in the study.

1.4 Purpose

The main purpose of the project is to make the inventory management more efficient. This due to the cutting process' impact on the company's business. An improvement of this area would lead to the company being able to put less time on handling and more time on value-adding activities. The study includes analyzes of the company's working process, layout of the cutting area and storage structure. It is expected that the result will provide a foundation for solution proposals that includes a new inventory disposal and how to improve the internal logistics.

2 Methodology

The methodology for the study is presented in this chapter. It is divided into three parts, literature studies, empirical studies and analysis finished with a piece about implementation. Literature studies is performed partly to support the empirical studies, therefore they take place in parallel. Based on the empirical studies, a description of the current state is created. Both the literature studies and the empirical studies have then been the basis of the analysis. The working process is presented in figure 2.1.

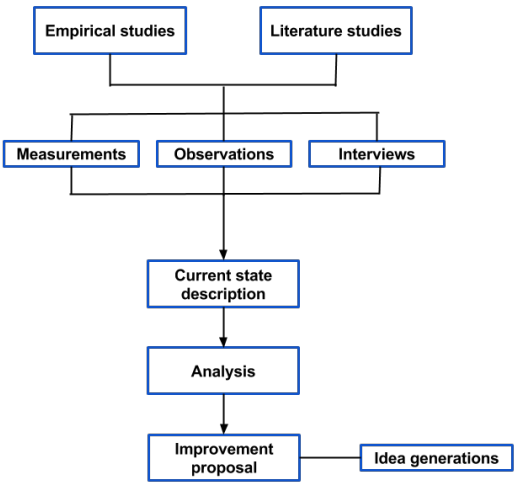

Figure 2.1: *The figure shows the working steps during the study*

2.1 Empirical studies

The empirical studies are an important part in the compiling of the improvement proposals. The purpose is to get an insight of how the production layout is formed and how the work is performed today and thereby provide a basis for how it can be improved. The empirical studies includes the research method case study, qualitative and quantitative methods and data collections that are described more detailed in the sections below.

2.1.1 Research method

Case study is a commonly occurring research method. Briefly a case study can be explained as an empirical study that allows the researcher to study a specific case that aims to provide a deeper knowledge in the specific area. Generally, case studies can be considered beneficial to use when "how" and "why" questions are asked, when the researcher do not have much control over behavioral events and the focus is on a real contemporary phenomenon. [**Yin**, **2014**] The purpose with this study is to handle a specific case in order to gain a deep understanding including the specific circumstances in the context. The study's two main questions are "how" questions and for these reasons, case study is considered as an appropriate method.

Research methods can be divided into qualitative and quantitative methods. According to Holme [**1997**] both methods have the same purpose but there is some distinct differences between them. Qualitative methods are based on interpretations and perception from the person who process the information, for example in social contexts. These results cannot or should not be reformzed into numbers because the method is based on own perceptions and to compare perceptions by using numbers would not give any information about the perceived event. Quantitative methods involve reformation of information to numbers and amounts used as the basis for analysis. A combination between the qualitative and the quantitative methods could make them compensate for each others weaknesses and therefore be beneficial. Bryman [**2011**] argue for use of several research methods and specifically mentions the combination between qualitative and quantitative methods which strengthen Holme's [**1997**] argument. According to

this, both qualitative and qualitative methods were used in the study. Quantitative methods includes calculations and measurements in time as well as distance and were used in parallel with the qualitative methods in terms of own observations and assessments of interview results.

2.1.2 Data collection methods

According to Dahmstrom [**2011**] information collection can be divided into two prerequisites, collection of new data and accommodation of existing information relevant to the current issue. New data is called primary data and the term secondary data refers to the data that exist from earlier work. An amount of secondary data from the company's business system has been used in the study, for example data on sales from 2016, placement for storing beams and total consumption for each beam variant in millimeter. The primary data that is collected is measured distances and process times in the factory as well as interviews.

Measuring can generally be described as systematic retrieval of information about variables resulting in a set of data. Measuring of capacity could be divided into direct and indirect measuring. Indirect measuring is when there is no directly physical representation such as attitudes and direct measuring in the other way have a direct physical representation such as weight. [**Befring**, **1994**]

Through observations, interviews and surveys collection of information can be done [**Befring**, **1994**]. The collection can be structured and strictly standardized or have a more open approach more based on impressions [**Dahmstrom**, **2011**]. Observations allows the researcher to use itself as a measuring instrument by listening, watching, feeling, experience and record their impressions [**Befring**, **1994**]. A prerequisite is that the researcher study something in their natural environment and create understanding based on that perspective. Observations include certain problematic in terms of ethics, validity and reliability [**Dahmstrom**, **2011**]. However, Befring [**1994**] believes that the pursuit of studying a phenomenon in such a systematic manner makes the data is valid and reliable.

Within research an commonly used form of interviews is outreach interviews or field interviews. In these type of interviews it involves the interviewer visiting the respondent in their environment, for example at home or at work. A interview can also be conducted with indirect contact, for example over the phone. [**Befring**, **1994**] Most appropriate method in this case is field interviews due to language barriers. During direct contact it is easier to understand each other and visualize questions. It also makes it easier to create a discussion. Interviews can be divided into formal, structured interviews and informal, unstructured interviews [**Befring**, **1994**]. Structured interviews include detailed interview guides with fixed questions while unstructured interviews often are expressed as conversations based on specific issues [**Befring**, **1994**]. The purpose with holding interviews at the factory was to create understanding for current processes and to take in improvement suggestions from the employees and relevant managers. Therefore informal, unstructured interviews was performed. This is because the exact information required for the current state description is specific for the situation and therefore not precise.

2.2 Literature study

A literature study was performed in an initial phase of the study which is important to gain knowledge within the area, therefore it is an appropriate first step. The studies have been conducted within warehouse logistics with focus on storing, picking and transport. The study's literature has consisted of books, e-books and scientific articles. The search has been performed by searching in Chalmers library system and in Google Scholar. A meeting with a librarian was held with the purpose of getting tips on keywords and getting information about which of the library's databases that is relevant for the subject. Relevant literature from earlier studies has also been used as references. The scientific articles that has been used is limited to recent years.

2.3 Approach

The study began with literature studies in warehouse logistics and empirical studies in form of interpretation of tables, charts and information given from Beam Producer AB. In order to gain a deeper understanding of how the production works, a visit in the factory are conducted. The visit shall be used to understand how the production processes works which is a requisite to be able to create a description of the current situation which in turn is essential to the final improvement proposal. The visit will also

provide an insight into the production workers thoughts on the present situation as well as an opportunity to collect their improvement suggestions. The factory is located in Eastern Europe and therefore the empirical studies is limited to four days, which was the length of the trip.

The literature studies contribute to a greater understanding in the field and are also the basis for the calculations that is performed. The calculations is a part of the analysis that starts with reviewing the various improvement proposals that has come up during the visit in the factory. Measurements of time as well as distance, observations and interviews of relevant employees and managers were performed. With the aid of the empirical studies, the calculations that, according to the theory, is considered appropriate, can be performed. The results of these calculations in combination with other, practical factors, is the material that is used in the development of the improvement proposals. The proposals are examined and through discussions in the basis of the analyzes, the options are sifted to see which proposals that are to be taken forward and which ones to sift out. After further review of the improvement factors, a combination of these factors can be presented in a final improvement proposal.

The solutions have not been developed by any scientific method but have been based on empirical and literature studies. The improvements that is mentioned later in the report is based partly on literature review but also on the current state and therefore from the empirical studies. Each company's situation is specific, therefore it is difficult to find literature that accurately describes problem solving for the specific situation. Therefore, some of the proposals have been based partly on own conclusions, ideas and idea generation.

2.4 Empirical studies in the factory

As mentioned, empirical studies were performed in form of a visit in the factory. The preparations and working process during the visit is presented in this chapter. In conclusion, how we processed the collected information is specified.

2.4.1 Preparations

Before departure, preparations were made in form of reading within the subject. During the preparatory work, questions emerged that were sent to the warehouse manager in order to prepare for the visit and give a picture on what we planned to look into during the visit. These questions are presented in *appendix 2*. Several of the questions was answered by observing the production flow by ourselves which indicates that the visit was a rewarding part of the empirical study. Without the visit it would have been difficult to understand the formulation of the problems which was more complex than what was interpreted from the files and through descriptions. Therefore, the visit is considered a prerequisite for completing the assignment.

2.4.2 During the visit

Four days were spent in the factory which mainly consisted of observations and interviews. The interviews began traditionally with asking question and getting answers and has then fallen into discussions about the situation in the warehouse. The observations were performed in order to understand the processes. The interviews and discussions was performed with those we were given the opportunity to talk to, which was our employee contact, the production workers, two team leaders, the warehouse manager and the senior manager. The purpose with the interviews and discussions was to get involved persons opinion about current situation and discover which parts of the processes that are well functioning and which parts that need to be improved. Notes from each day in the factory that describe performed handling were written in order to create a structure of what was performed and what needed to be done the following day. These notes are presented in *appendix 3*.

2.4.3 Processing of collected information

The company has a speed limit of 5 km/h, which equals 1.39 m/s. Measurements of the forklifts driving time and the driven distance were performed in order to calculate the forklift's speed meter per seconds in reality. A compilation of the calculations is presented in *appendix 4*. During measurement of the forklift's speed, variations between the values were noted. Partly differences between the speed horizontally and vertically, where the vertically speed was slower compared to the horizontally speed. It was also observed

that the forklift moved slower vertically when the fork was loaded with material compared to when the fork moved without material. Horizontally, no difference in speed was observed whether or not material was transported. For example a measured horizontally speed is 2.0 m/s, a measured speed vertically without material is 1.0 m/s and a vertically speed when the fork was loaded with material is 0.4 m/s. Other variations between the values occurred because of the forklift unplanned had to stop along the way. These stops usually occurred during horizontal transportations. The unplanned stops could consist of disturbing activities linked to other processes such as if two forklifts need to pick or deliver material from the same aisle, when this happens one of the forklift's need to wait before passage can take place. It could also be maneuver of the forklift in order to drive past any obstacles along the way or stop that appear when a employee meet another employee during the ride and stop off to discuss something. These unplanned stops lead to waiting time which make the calculated values misleading because the values for the speed in meter per second gets lower than the reality speed due to the waiting time. It is noteworthy that most of the transportation within the factory is done horizontally, the vertical movements was only a fraction of the total forklift activities. An observation was that mainly, the unplanned stops happened more frequent the closer the forklift drove to the area with inbound, packing and outbound activities (*see figure 4.2*). Within the area closer to the inbound, packing and outbound, there is a greater risk of collisions with processes in other departments because their processes include activities that is performed within the area for inbound, packing and outbound. A factor that make the vertical values misleading is that the production workers moved the fork vertically while the forklift moved horizontally. This is something that is not allowed due to the company's prescript that says that the fork should be in driving position during the ride. It can be established that the calculated speeds are lower than the actual speed in reality. Due to the source of error on the measured values that make them misleading, the speed limit on 1.39 m/s is used as a basis for the speed both horizontally and vertically. This is based on that the most of the forklift tours take place horizontally and during horizontally movements, when the forklift actually moved, the forklift tend to go faster than the speed limit.

3 Theoretical frame

In this chapter, the theoretical background that is relevant for the study is presented. The theory is the basis for the empiricism and the analyses and the chapter also aims to give the reader an introduction to and understanding of the subject field. As mentioned, the problems are divided into two main questions regarding storing and layout.

3.1 Storing

When creating a physical storage, the aim is to minimize storage costs and handling costs. This by achieving high degree of filling and low operating costs. It is created by utilizing as much as possible of the storage space without complicating the handling. For example, there must be enough space for transportation aisles and certain number of empty storage places to address variation in storage need. By placing high frequently items so that the transport distance gets minimized, while low frequently items can have longer transport distances in the warehouse, the most unnecessary transfers can be avoided and minimized. How easy it is to find the material and access and move it are other factors that affects the handling costs. Therefore, the high frequently items should be placed in the most easily accessible areas. [**Jonsson & Mattson**, **2011**]

3.1.1 Zoning

The handling work can be minimized by dividing the stock into different zones. The zones should be designed so that the items with equivalent handling frequency are grouped and placed in the same zone. The handling frequency can be expressed as the withdrawal frequency, which is how often an item is taken out of the storage. If the items are sorted according to their respective withdrawal frequency, it is not uncommon that 5% of the articles account for up to 50% of the picking activities. Similarly, the 20% of items with the highest withdrawal frequency relate to 80% of the picking activities. In that case, the remaining 80% of the item assortment are picked at a low frequency corresponding to 20% of the total picking work [**Jonsson & Mattson**, **2011**]. The group of articles with the highest frequency of withdrawal should be placed in a zone so that the handling work is simplified as far as possible and the groups of articles with lower picking frequency should be lower prioritized and placed in zones that are not as easily accessible. [**Jonsson & Mattson**, **2011**] This type of storing, using zones that are created after the handling frequency of the items is a way to determine which placements that are best from an efficiency perspective. The zones that are created will further in the study be referred to as the hot zone.

3.1.2 Article placement in the storage

The article placement is another deliberation within the storing which can be either a fixed or moveable. A fixed placement corresponds to a predetermined storage space for each item and a moveable placement corresponds to unspecified storage placement, but items are placed where space is available. An administrative storage system keeps track of where each item are stored. A larger total storage volume is required for fixed storage location than in moveable storage location. This is because the storage space must be dimensioned according to the maximum storage volume for each item which is a disadvantage of fixed storage location. [**Jonsson & Mattson**, **2011**] The advantage is that the storage layouts can be more easily customized so that items that are picked or managed high frequency can be placed close to the loading and unloading areas while low frequencies can be placed far into the storage. Through this, the total handling work can be minimized and the inventory utilization improved. To combine a fixed and a moveable storing system is possible. It is common to use fixed system for the picking stock and to use moveable placements for the buffer stock. The material in the buffer stock is then moved to fill the picking stock. [**Jonsson & Mattson**, **2011**]

Another issue is to find out which products to store at floor level and which ones to store at higher heights. The area at the floor space and just above the floor space is the most easy accessible area for the material handler, withdrawal can be done by hand or by a forklift. In order to pick up materials from higher altitudes, it is necessary to use a forklift and normally, the time for loading and unloading is longer. Weight and volume also matters in the placement of materials. Normally heavy material is placed on the floor and low frequent and lighter material is placed on a higher heights. To use the lower level as a picking stock and to use higher levels as a buffer stock is also common. [**Jonsson & Mattson**, **2011**]

3.2 Efficiency variables

The production logistics primary purpose is to improve companies efficiency which in turn should lead to increased results [**Jonsson & Mattson**, **2011**]. The efficiency can be expressed in so-called efficiency variables. By measuring and pursue the efficiency variables, behavior in the company can be influenced and create conditions for efficiency. The majority of the variables are contradictory and do not function to be combined. Because of this, some priorities between the variables usually have to be made. It is important not to optimize an individual efficiency variable but instead striving to find the overall best efficiency. The efficiency variables can either have a direct influence as revenues and costs or an indirect influence as the flexibility and timing properties. [**Jonsson & Mattson**, **2011**]

3.2.1 Direct efficiency variables

Customer service affects the company's revenue, it contains all activities the customer is offered in connection with a business deal. From the beginning, the offer consists of only a physical product but as the product is processed, various services are added, such as dimensioning of measurements and delivery of products according to the specified time. [**Jonsson & Mattson**, **2011**]

According to Jonsson and Mattson [**2011**] the part of the customer service that the logistic system can contribute is by creating good the delivery service, provide information about the material flow and other logistic services. A mix of service element creates customized customer service together. These elements are more or less important depending on the situation. Deliver flexibility is a service element that refers to the ability to adapt to and meet changing customer requests in the agreed and already ongoing orders. For example, this may be a matter of changing delivery dates or order quantities at short notice, which is a common requirement from subcontractors. In most situations, the length of the delivery time and to which extent the promised delivery time is hold are important elements. Material flow methods can be used to create customer service by enabling information exchange in order to reduce planning uncertainty for involved parts. Other logistic services refer to the additional services beyond the product itself which many offers are combined with that can have positive impact on customer service. Examples of such services are to provide the product with a customer specific package or label, to pack it with other products or to provide the product with barcodes to simplify for the customer later. [**Jonsson & Mattson**, **2011**]

Companies costs is affected of several variables. Physical handling, movements and storage of material are examples of activities that give rise to different types of costs. Expenses for administrative staff and information systems in order to plan and control material flows are some components that the logistic system gives rise to. The capital formation along the material flow also creates logistic costs. In case of defects and delay of products that occur when one order cannot be delivered according to compliance, activity costs incurred to compensate for this. [**Jonsson & Mattson**, **2011**]

3.2.2 Indirect efficiency variables

According to Jonsson and Mattson [**2011**] the ability to vary the production and delivery volumes affects the flexibility of the logistic system. It can be divided into three regions: delivery flexibility, product mix flexibility and volume flexibility. The definition of delivery flexibility is the ability to achieve delivery changes if necessary to adapt the customers changing needs. Product mix flexibility is described as the ability to rapidly adapt production and material supply to changes in demand between existing products and product variants. This means to be able to quickly reset and produce more of certain products and less of others. Volume flexibility refers to the ability to quickly increase or decrease production and delivery volumes regardless of whether or not product mix changes occur. Delivery times on articles, throughput times, series sizes in the production and the degree of overcapacity that is the capacity utilization in existing facility determines the volume flexibility. [**Jonsson & Mattson**, **2011**]

The time affects other efficient variables and therefore becomes a key part of the logistic system because it is difficult to create an overall efficient logistic system without it being time efficient. It is required that the throughput times and the setup times in the own operations are effective to be able to offer the customer a short delivery time when designing or manufacturing against customer orders. If the time for the activities performed from the moment that an order is received to the delivery is not optimized, the delivery time risk being longer than perceived as acceptable for the customer. It also conduces to tie more capital in the material flow and to that it takes longer time to react to changing customer requests. The obsolescence risk, the risk that the products not will be sold when they become available increases

during a long throughput time. Short throughput, setup and delivery times also improves all flexibility variables because it then goes faster and becomes less expensive to make changes in already accepted orders. [**Jonsson & Mattson**, **2011**]

3.3 Automation in warehouses

In a project Hackman, Frazelle, Griffin, Griffin and Vlasta [**2001**] have searched for if any parameters could be correlated to high efficiency. Due to logistic trends that began in the 1980's, several warehouses invested in automation in order to make productions more efficient. The project Hackman et al. [**2001**] were involved in researched how high automation levels is associated to the effectiveness within a warehouse. The results showed that high automation levels on the contrary were associated with low efficiency. The level of effectiveness is related to the size of the warehouse where larger warehouses with high level of automation tend to be less efficient compared to smaller warehouses with high level of automation. The conclusion in the project was that warehouses using low level of automation tend to be more efficient than the warehouses with higher level of automation. [**Hackman et al.**, **2001**]

3.4 Conflict of aims between departments

Conflicts of aims may occur between companies different departments. These arise as the effect of companies operating as functional organizations. By this means that departments are specialized and focus on their own defined tasks and endeavor to only minimize their own costs and capital formation. This eliminates the overall view of material flow and actions for the best of the wholeness do not occur. Suboptimization, optimizing of individual departments at the expense of the overall efficiency easily arise with such an approach. That an employee focuses on performing the tasks in order to satisfy the manager instead of the customer is another effect that generally can be described as that the focus are on efficient resource use instead of customer value. [**Jonsson & Mattson**, **2011**]

3.5 Layout

A layout is used to show how an area is designed and is often used as a tool for improvement of production systems and as a description of how the production area should be structured. From a drawing it is possible to sketch on different proposals and evaluate how to make the best use of the surface. Layout planning is a plan for how industrial facilities should optimally be arranged. [**Bellgran**, **2005**]

The design of every specific work space is done by bringing the technical, work organization and work environment together in such a rational way as possible. There should be a balance between the demands the work assignment entails abilities to solve the task. These skills can be ethnicity, gender and age and the goal is to offer a work environment that satisfies both physically and mentally. Whether the work organization is successful controls the motivation, well-being and motivation of the staff and the work rate which in the long run affects staff turnover, sick leave and so on. [**Bellgran**, **2005**]

A production system should aim to, with associated work organization, provide the opportunities for each individual to perform their task, but also encourage process development. To make use of each individuals unique competence and to have an environment that motivates problem solving is at least as important as just solving everyday tasks. The attitude of the employees and corporate culture is so important that it can't be mentioned enough. [**Bellgran**, **2005**]

Systematic Layout Planning (SLP) is a useful tool when planning a layout that was created in 1961 by Richard Muther. SLP is a systematic and relatively simple method while it is well-tried and has been used in the formation and layouts during the last decades. [**Yang**, **Su & Hsu**, **2000**] According to the creator, Muther [**1973**], there are several aspects to have in consideration when forming a new layout. The two main elements that is analyzed is the type of products and sales volume for future production. So SLP is used to create a new layout that fits the future needs of the business.[**Muther**, **1973**] SLP is a step-by-step method where analysis of input parameters and activities are done to evaluate a layout design. The method provides a new factory layout that improves process flow and increases the available factory space. [**Wiyaratn & Waranapa**, **2013**].

3.6 Material flow

The primary flow in logistics is the material flow from source to the final consumer. The material flow represents big values and do have direct effect on the environment and do in many situations demand big resources to be able to execute. The physical material flow can be connected to four different kinds of system components depending on which type of flow that is referred. The movement itself may happen between establishments or within establishments. Handling of material in connection with reception of goods, entry and withdrawal from the storage and loading on external transportation means relocation within a facility. Transportation and handling of material is done between different locations within the factory and is therefor material flow related components. The material that flows through the system is enclosed by some type of packaging. The design of the packaging have an direct effect on the transportations, handling of material and the storing. The packaging can therefor also be seen as a component related to the material flow in the logistic system. [**Jonsson & Mattson**, **2011**]

SLP handles material flow during a step of the method. This step sums up the flows within different process steps to be able to determine the intensity of the flow. This can be done with a "from-to"-diagram where every transport is summed up to an intensity of the flow during a time period [**Yang et. al**, **2000**]. According to Wiyaratn and Watanapa [**2013**] the distance between the activities should also be measured to give an indication on where long transportations are made. The goal with the layout is according to Wiyaratn and Watanapa to get a progressive flow with as little back flow as possible and to place the machines with the highest flow of intensity close to each other. This steps analyzes quantitative data and ties together several of the input parameters.

3.7 Activity relationships

When creating a new layout Muther [**1973**] claims that only analyzing the material flow will not be enough. Muther [**1973**] mentions that some of the production steps can have a negative effect on peoples health and products and needs to be held separately even if it can effect the material flow negatively. A step in SLP analyzes the qualitative factors to be able to evaluate which activities what should be close to each other through a diagram of activity relationships. Factors that according to Muther [**1973**] should be in considerations are the ability to communicate, the use of shared tools, the area for operators, comfort for the staff, supervision, environment and safety, disturbances and interruption and lastly material flow.

When designing the space there are several factors that needs to be taken in consideration, everything important needs to fit in on a limited area. Within SLP step five to seven involves looking over the space, and when deciding the space for a machine it is important look at the forecasted sales. This is to be able to provide space for a higher capacity of staff and material as well as the access to support functions for a future growth. [**Muther**, **1973**]. This so that the layout does not need to be redone each year when the company grows.

When analyzing the changes in a layout during the end of the process it is to look to the important aspects of the handling of material flow and how the storing is supposed to be done. The space for maintenance, security aspects as well as the space for employees needs to be looked over one extra time, this due to changes that may emerge. [**Muther**, **1973**]

With every change and compromise pros and cons needs to be taken in consideration. According to [**Muther**, **1973**] this is due to practical limitations in each one of the changes. There can be practical limitations in installation in an otherwise automated and balanced product line. When considering changes in different layout proposals it will ultimately make it possible to narrow the proposals down to a few layout ideas that can be evaluated once again before making the final choice.

A clear explanation of each of the sieved proposals should be presented to different members of the organization [**Muther**, **1973**]. According to Muther[**1973**] there is three methods that can be used to evaluate developed layout suggestions. A method to use is to make a list of pros and cons for each of the suggestions and then pick the option with predominant cons. Another method is factor analysis where important factors from the new layout is listed. The factors are then given points after importance, the factors from each layout is then summed up and the layout with the highest sum is the best suited layout. The last method is an evaluation of costs. It should partly be analyzed in order too see if it is economically viable for the company to make an investment but also to put the various layout proposals against each other economically. According to Muther [**1973**] there are two ways of approaching the costs, either an analysis of the total cost which should be done when doing a whole new layout or only the costs effected by the project which should be done when only making rearrangements of a layout.

3.8 Human factors

Employees often demands more then just salary, they want attention, showed interest and security. At the 1910's the early work sociologists and psychologists started their researches about which factors that could effect productivity. Elton May was one of them and he opened up laboratories for studies including fatigue and monotony. During the 1920's and 30's the Hawthorne studies was performed. In the factories where the experiment was being performed there was a recurring trend of strikes, and great dissatisfaction regarding the working conditions and the factory with about 30 000 employees had high turnover on workers and terrible production results. [**Bruzelius**, **2011**] After work sociologists and psychologists failed to help the company correct the errors so they took help from the American Academy of Science. These scientists where trained within social studies and was given the opportunity to solve the company's practical problems. The studies made lead to the discovery of "the social human being", a person is human on the workplace as well and wants to be treated like that. The Hawthorne study was performed by a lightning experiment. The ones leading the experiment assumed that the amount and quality of lightning effected the productivity, and so was the case. But something that was not expected was that the productivity increased by both improvements and deteriorations of the light conditions. When this was discovered the study was extended to look over more of the working conditions. It showed that what ever was done the productivity increased, something that was considered strange from the scientists perspective. The conclusion later became that the employees, even if the working conditions deteriorated, appreciated the attention and that the management had interest in them and their working conditions. This is now called the Hawthorne effect. Productivity is not only based on technical and physical conditions but also on social norms, therefore it is not only the managers but also the group of employees that determines how much that is produced. [**Bruzelius**, **2011**]

4 Organization

Beam Producer AB's organization is presented in this chapter. Several steps, more or less detailed are explained in order to create understanding for the entirety flow.

4.1 Product offering

The company perform three different customized orders which are customer orders (CO), manufacturing orders (MO) and distribution orders (DO). CO's are divided into two different sections, CO2's that goes to external customers and CO7's that goes to Beam Producer AB's own sale company, that currently is located in the same building. MO's contain material that is used for building larger systems. The area where those systems are built is also placed in the same building as the production. DO's are material that is shipped to Beam Producer AB's own factories in other countries. The company's business concept to external customers is to deliver to customer the day after the order is placed. Out of these three order types, only CO's goes directly to external customers and therefore CO's have the top priority in the production. As mentioned, MO-material is used for building systems in the factory that later on is sold. These orders also goes to external customers in the end and are therefore prioritized after CO's. DO's are internal customers so their offer do not need to compete with other companies on the market. These orders are gathered and made two to three times a week and then delivered.

4.2 Material handling

The material is divided in three different variants and these are beams of different kinds, plastic material and pipes. The most frequently used material is the beams, the other material is more rarely used. All the material comes from external suppliers and is delivered in cardboard packages. Because there are different varieties of the material, they are handled in different ways. Most of the beams are heavy or placed on a height hard to reach by hand and thereby needs to be picked with the forklift. In the most cases the production worker drives the forklift from the picking area to the location of the material, picks the beams and then transports them back to the cutting area and places them on the working station. The forklift must pick up all the material that is stored in a specific pocket all at once and cannot pick just the amount that is needed for a specific customer order. Therefore lighter beams, plastic material and pipes is supposed to have a placement close to the floor which gives the production workers the opportunity to pick the material by hand, which also makes it possible to only pick the needed amount and not the entire package. Even in this case the material is placed on the working station after the picking. Stickers with information about the length and the item number of the cut beam is put on the CO2's and on the DO's but on the CO7's and MO's the length of the cut beam is written on the beam with a pen.

The CO2's are transported directly to the packing area. For CO7's, MO's and DO's, a pallet is placed on the transport table and the beams are placed on the pallet. The pallets are used when the beams are stored on shelves before further production or packaging steps is done. CO7's are transported to the sale company and MO's is transported to the production area which is two locations in the factory. DO's are transported to the packing area. Some orders are supposed to be drilled in a CNC machine and for all those beams, where CO's, MO's and DO's are included the beams are placed on a pallet as well. The beams to be drilled is transported to shelves close to the CNC machine.

The plastic material and the pipes are often sold in a high quantity with a short length, therefore the material is often taped together, to make sure that the material is tight together, and then cut in the automatic machine to be able to cut several pieces at a time. After the cuts are done the tape is removed.

4.3 Conversion

As mentioned in the background, section 1.1, Beam Producer AB offers the customer to order beams either in pieces or in millimeters. All beams are delivered from the distributor and either comes in the lengths of three or six meters, but these measurements are not exact. These beams are placed in the storage on the pockets that are empty at that moment, except for a few high frequent beams that have standard placements in the storage. If the customer wants exact measurements the beams needs to be ordered in millimeters. The beams sold in pieces are therefore sold for use without exact measurement. When the beams are delivered to Beam Producer AB they are placed in the storage area as pieces, and

then needs to be converted to millimeters in the system. When the conversion is performed, the beams are moved from their placement as pieces to a new pocket to be able to separate the millimeter beams from beams sold as pieces. The millimeter beams have no standard placement, they are placed where there is empty pockets in the storage. The only way to see the difference between the beam sold as pieces from the one sold as millimeters is to look in the computer system. The conversion is done continuously each day, but can also be done by the operators when there is a need. Conversion in this case means changing the beams sold as pieces to beams sold as millimeters. The first step is to look where there is free space in the section for millimeter beams and then to move the beams sold as pieces there. After that the move is reported in the computer system and that makes the item number of the beam change so the beam is registered and found in the system as millimeters instead of as pieces and the conversion is done. A customer order can include both beams sold as pieces and millimeter.

4.4 Machines

The production area has two sizes of cutting machines, four big ones and one small. The big saws is in the greatest extent manual while the small saw is automatic. One of the big machines has been moved away from the production area, this because it was not being used. The production workers have got instructions to try to use only two of the three remaining big machines, this due to that the machines are not used efficiently and by the workload two big machines and the small one should be enough to manage the all the work. Before and during the study, Beam Producer AB are discussing the opportunity to invest in a automatic storage machine. This kind of machine is supposed to have about 30 placements and automatically deliver the needed material to the operator by one of the cutting machines. To be able to use the machine efficient, every item placed in the machine need to have two placements each. This is because the material needs to be able to be refilled before the pocket is empty. This makes the machine to accommodate place for 15 different beam sorts.

4.5 Division of labor

For the production there are two shifts, shift A and shift B, these two rotates with working an early or late shift weekly. Shift A are three workers and one extra if needed who works mainly in the packing area. Shift B are four workers without any extra. Each shift has a team leader, and is the one responsible for the workers, but not only the ones working in the production but the whole shift that includes several departments in the warehouse. Within the cutting area, the team leaders responsibilities is to receive the orders, distribute the work and makes sure that all work during the shift runs smoothly. Between the early and late shift the team leaders from each shift have a short meeting to give a handover on what has been done earlier during the day, what should be continued with and if there have been any problems that needs to be noticed. The early shift is between 06:00 and 14:00 and is responsible for doing CO 2's. The late shift starts at 14:00 and ends at 22:00, the shift is responsible for finishing the CO 2's that are left from the early shift and then later continuing in the following order with CO 7's, MO's and DO's. The evening shift is also doing all the continuous conversion and has one person only doing that the entire shift and is also putting in the delivered material from suppliers. Both the early and late shift often work overtime, between two til four hours, several times a week. This is due to the high demand of the company's products as well as the low unemployment rate in the area.

The company has recently started to implement a new method that changes the division of work. Instead of each worker doing the whole production process individually, which was done in the old method, the process is divided to that one person is the one managing the forklift for the whole shift. This means doing all the transportation to and from the cutting area to either storage or packaging, while the other two is by the machines doing only cutting. The forklift driver is also responsible for doing the work around the cutting like printing stickers, and doing conversion from pieces to millimeters if needed. The employees circulates the work assignments each week, so that everyone in the staff has the possibility of not doing the same thing all the time. Since the

4.6 Employee impact

Beam Producer AB have implemented the improvement method Kaizen in the way that all employees have the opportunity to come up with improvement suggestions. These suggestions is evaluted by the management with purpose to take relevant ideas further. Several of the production workers utilized the opportunity at a regular basis.

4.7 Layout

The current layout is presented in figure 4.1. The cutting area contains three big cutting machines, these are handed manually. One of these, cutting machine 2, is a newer model and has the possibility of being used more automatically, but is still used in the same way as the other ones. There is one smaller cutting machine that is fully automatic and is used to cut many small lengths of material. This is partly because it is done faster but also since there is a risk of doing small pieces in the manual machines. By each machine, both the small one and the big ones, there are transport tables. On these the finished cut beams are placed to collect the order to later be picked up by the forklift. By each machine there is also unloading stations, these are trestles placed in pairs where the packages of uncut beams are placed before the operator cuts them. By the big cutting machine placed in the left corner closest to the beam stock there are two extra pieces of equipment. Partly a crane that is to be used when the beams are to heavy to lift from the unloading station to the machine by hand. By this station there is also a table where the operator is able to have extra space to facilitate the processing of the beams that is done after the cut. By the left wall there are a rack where scrap pieces of frequently used beams are stored to be able to reuse. The racks contain several different type of beams. By the same wall a locker that stores dangerous liquids, like different solvents used by the entire factory. The locker is connected to a ventilation system that has a fixed location by the wall. The recycling station is placed by the back wall with three different containers, one for plastic , one for cartonage and one for aluminum where the scrap pieces of beam are thrown.

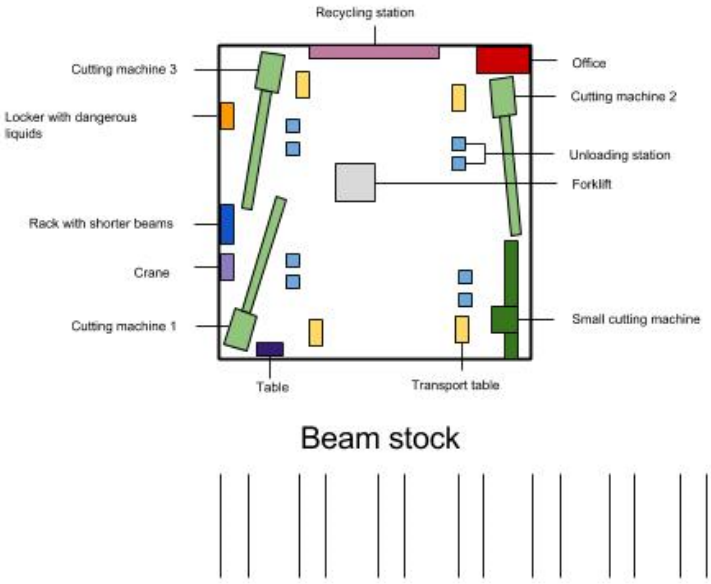

Figure 4.1: *The figure shows the cutting area and current layout within it. Where the beam stock is located in relation to the cutting area is also shown.*

4.8 Description of current production process

The production process begins with the customer placing an order which is registered in the company's computer system. The team leader on current shift structures a picking list in order to make the information easy to grasp. The picking list contain information about which specific beams that are demanded, orders mostly contain several different beam types. In which lengths the beams are to be cut in and information about where the material is stored is also shown on the picking list. The team leader prints the picking list and the production workers can then derive the picking list from the team leader's office. (*See figure 4.2.*) Then the production worker uses the picking list to compose and complete the order.

The first step in the cutting process is to pick the material from its placement, transport the material to the cutting area with the forklift and then place it on the unloading station (*See figure 4.1.*) The packages are sealed with packing tape that the production workers opens up with a knife and then, if possible, the beam is moved by hand to the cutting machine. If the beam is to heavy or to hard to handle two production workers does the lift together. By cutting machine 1, there is a small lifting crane that can be used to do the lift. The settings of the cutting machine is done according to the order and the beam

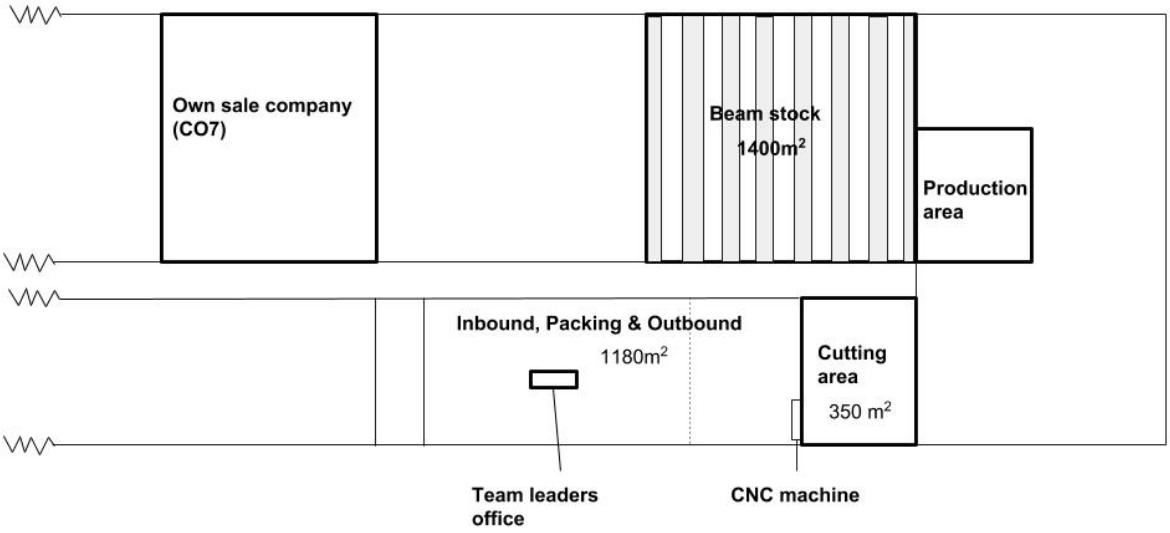

Figure 4.2: *The figure show departments within the warehouse that is connected to the cutting process.*

is then adjusted to the right position and then the cut is done by the productions worker by pressing a button with each hand (for safety reasons). The average cutting time is 22.7 seconds, see *appendix 1* for calculations. After the actual cut the beam is in several steps that together creates a mean time. First, the beam is cleaned to remove marks, metal chips and sawdust that may appear during the cutting process, this is done by using a special eraser and rubbing alcohol. The beam is then labeled, either with a printed sticker or with a pen directly on the beam. The average mean time is 35.6 seconds (*for calculations, see appendix 1*). After the mean time activities is performed, the beam is put on a transport table from where the forklift can pick up the whole table. When the forklift pick up the transport table, the material that lays on it contains all the customized material (millimeter material) for the entire order. The material is transported to different locations in the factory depending on the order type.

5 Analysis of current state

In this chapter an analysis of the current state is presented. It is partly based on our impressions and observations from the visit in the factory, but also based on interviews and discussions with employees and managers in the factory.

5.1 New method

As mentioned, the company has recently started to implement a new method that changes the division of work from each individual doing the whole process to dividing the work into different assignments. During the visit the old method was only shown one day as a demonstration of the method. Therefor the study here mostly relies on comments and opinions of the employed at the factory.

According to several of the operators, a problem that appears with the new method is that since there is no buffer the forklift driver needs to pick up the used material from the unloading area and drive it back to the storage before the next material in line can be picked up and delivered to the operator by the cutting machine. This is especially noticed when making CO7's and the forklift driver has to drive to the other end of the factory before being able to get new material. This is done since there is no place for the operators to place the cut beam until the finished order is removed. This process generates a lot of waiting time for the operator at the cutting machine. Forklift driver A also mentions that it is hard to keep up with both cutters, if they both finish an order at the same time, there will be even more waiting time for the operators by the cutting machines.

5.2 Conversion

An activity that is time consuming is the conversion. In discussion with both team leaders and the employee contact, they all agreed on that the biggest problem is the conversion. It is a time consuming activity that takes time and thereby indirect slows down the cutting process because one employee needs to make the conversion instead of help with the cutting process. And with the new method, as mentioned, it is hard for the forklift driver to keep up with the work for the cutting machines, but the forklift driver is also expected to do conversion in parallel with this.

5.3 Buffer

Today there is no distinct buffer solution, they sometimes use the unloading stations by other cutting machine's work stations not being used. This is a solution that is not sustainable because it is a distance for the operator to move material from that work station to their own. The operator also need to go between the work stations after each cutting cycle to get new material when this solution is used. There is no smooth way for the forklift to be able to unload the material that is up next for cutting that is easily accessed for the operator by the cutting machine, while the forklift then easily can pick up used material that is to be transported back to its place in the beam storage.

5.4 Material flow

The visit in the factory together with measurements showed that the actual cutting time is not a bottleneck. On the contrary, the cutting machine stood still because the lack of workload while the picking activities were performed. When the old method was used the production worker responsible for a cutting station had to restore used material to the beam stock and pick up the material coming up next from the beam stock between the cutting activity. When the new method is used, the production workers mentioned that there is waiting time between the cutting activity because the forklift driver cannot keep up with the pace of work. The cutting machines is not used efficient because the machines do not perform cutting activity all the available time. The machines are capable of cutting several beams in the same cutting cycle which also can shorten the actual cutting time per beam in the cases where multiple beams of the same length has been ordered.

One of the operators sees a problem with picking lists of CO7's. For every CO7 the operator needs to take the picking list and go to the computer to see if there are any angle cutting or drilling that should be done. The problem with wrong or lack of information on the picking lists appears about two times a

week, but the operator needs to check every picking list for CO7's so there is no information left out. The team leaders get drawings on the CO7's and have started to try to attach the drawings to the picking list, but there is still an extra step that has to be done in comparison to CO2's. Team leader A also mentions that there is a problem with not using the full potential of the machines, there are a lot of steps that can be done by the machines, but is done by hand today. A comment from the senior manager is that the factory is missing a lot advanced technique that is on the market, and that the process will most likely move more efficient if an investment would be done in this area.

A forklift driver thinks the storage area is messy, and that not all the beams are placed in a good position. An operator sees a problem with that it sometimes is hard to find beams in the shelves, since they sometimes are miss placed, and for someone new it is hard to see the difference between different beams. This sometimes leads to orders being sent off with the wrong types of beams.

One of the forklift drivers mentions that in the cases when an order include both beams sold in pieces and millimeters, he cannot pick up all the material that is needed for the entire order, only the millimeter beams due to the process setup. Sometimes he has time to pick up the pieces beams as well but because the process setups he cannot. According to one of the forklift drivers, it is a problem because it is not time efficient. The senior manager sees the workload for the forklift drivers as one of the main problems in the production, there is a lot more then just transporting material that is assigned to the forklift driver.

5.5 Layout

The current layout makes it easy for the forklift to access all the workstations and the recycling station. Commonly for all the working stations in the current layout (*See figure 5.1 below.*) is that a unloading station and a transport table is placed in conjunction to the cutting machine. Connected to cutting machine 1 there is also a table which is something that is appreciated by the production workers who wants to work at that station because of the table. During work at the other stations, where there is no table the operators tend to create their own surface area because it is needed. An example of such a solution could be to put a cardboard on a waste bin. From our perspective, we saw the rack with shorter beams as a bit messy but the operators did not agree, during discussions they mentioned that when experience is gained, it is possible to memorize the frequent used parts of the assortment and thereby it is not a problem to distinguish the beams from each other. To have several different beam typed on the same rack is therefore not a problem. It is good that the company takes its responsibility and recycle. The layout is planned so that all components is easy accessed which is a prerequisite for a functional process. It is good that cutting machine 1 have a connecting crane, but according to the operators, it goes faster for two operations to move heavy beams instead of using the crane. Therefore, it is good when the operators are operating on working stations close to each other.

The office placement is a factor about the layout that could be improved. Due to that other people, like operators from other departments and the team leaders visit the office, it causes unnecessary movements within the cutting area. The same reasoning applies on the locker with dangerous liquids. According to the warehouse manager, relocation of the locker would be expensive because of the ventilation system connected to it. But relocation of the office is not a problem. The office is built by the operators with material from the warehouse so to rebuilt it on a other placement is not a difficult project. The operators mentioned that when they use the new method and only two cutting machines are used it is good to use two stations located close so that they easy can help each other with heavy lift, but because cutting machine 1 have a table and cutting machine 2 is a newer machine are those machines usually used which are located far from each other. The lack of buffer is another problem with the current layout when using the new method.

It is important that the unloading station is placed close to the associated cutting machine to easily move the beams between them. This is a important factor to consider as it facilitates the processes. To have the recycling station close to used the working stations is another factor to considerate because all stations uses them. This factor have a lower priority than than having the unloading stations close to the cutting machines because the operators do not recycle material as frequent as they need to refill the cutting machine with material for next cutting cycle.

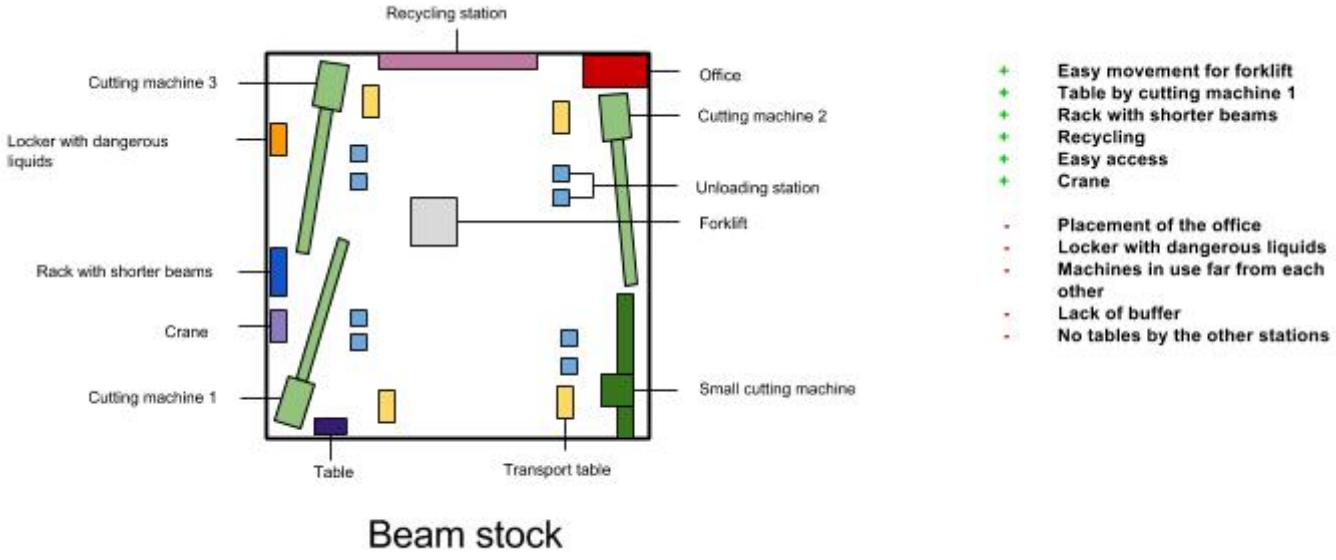

Figure 5.1: *Current layout.*

6 Solution proposals

In this chapter different solution proposals that is created with the analysis as a foundation will be discussed. The problem solving is a continuous process during the study that contains techniques as observation, interviewing, measuring and discussion. These factors are used in conjunction with the information from the theory in chapter 3 in order to identify the problems. Further, conversations with our supervisors and our contacts in the part of the company located in the Eastern Europe have taken place continuously during the project which also contributes to the discussion.

6.1 Buffer

When observing the work when the new method is in use there are both pros and cons. The actual cutting is more efficient by the stations, but there is a lot of waiting time for the operators. In the use of the new method it would therefor be beneficial to have another person on the shifts, so it would be possible to have two persons by the machines doing cutting and two persons driving forklifts. This is a proposal that is well addressed by both production workers and team leaders. When discussing the new method with both team leaders and production workers some preferred the old method since the workers always had something to do and there was no waiting time for them. A comment from Team Leader A was that the method works good when doing orders for external customers, CO2's, but when doing CO7's the one by the machine needs to wait for the forklift driver to deliver to their own sale company in the same building before getting new material, which is a real waste of working time. Team leader B thinks the new method works good when he has a full crew, having two cutters, one driver and one doing conversion, but otherwise he has the same opinion as Team leader A. This is an opinion shared by all the production workers during shift B. As mentioned in the analysis, when using the new method there is a lot of waiting time for the operator especially when doing CO7's. The forklift driver has to deliver the finished order to the company's own production before getting new material for the operator. We thought of changing the work order, that the forklift driver would leave the used material and get new material before delivering the finished order. The problem is that the operator won't have a surface to place cut beams for an order while the forklift driver is away. This might be solved with placing extra tables by each station so that the material can be placed there until the forklift driver can place another transport table by the station.

When discussing different buffer solutions with the employees many mentioned the automated machine which we think is something that likely relies on the discussion that has been held with two of the mangers, who puts big weight in making the process more automatic. This is something we later discussed with our supervisor at the company who thought that an automatic machine would be fun to implement, but the focus should be on making the process they have as efficient as possible before putting new components

in to the process.

We discussed having wheels on the unloading stations, so the unloading stations with material laying on them could be moved by hand. The wheels needs to be able to lock when they are placed in the desired location. When we discussed the idea with the senior manager he mentioned that the company already had tried it, but it did not work. When placing some of the heaviest beams on the unloading station, it was impossible to move them by hand because they were too heavy.

6.2 Placement of beams

Today there is no standardized way of storing the beams, they are placed where ever there is space in the beam stock. The comments from the workers on today's placement has been varied, much of this we interpret as being about habit. The specific placements can be described in three dimensions which are row, shelf and pocket. An explanation of how we further will describe a specifc placement is shown in figure 6.1 below. Beam producer AB have currently a goal of trying to keep all the millimeters in the first shelf of every row, by XX-01-000. This is maintained fairly good, but interpretations and calculations have been made that shows that this placement is not optimal. Below ideas and suggestions of new storage alternatives are discussed.

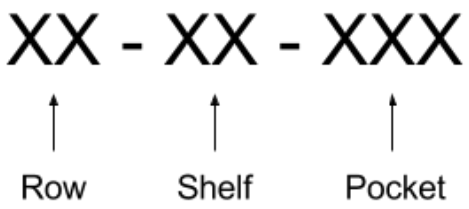

Figure 6.1: *Designation of location*

6.2.1 All beams in the same row

Having all beams in the same row is something our supervisor from the company mentioned early on during our visit in the factor. The idea of placing all the millimeter beams in the same row would involve placing the beams the row closest to the cutting area, shelves 58 and 59. *(see figure 6.2).* This is a proposal that was discussed with the production workers and team leaders. The opinions about one row is spread. One of the operator likes the current storage layout and do not see a need for change, but is open to changes if other thinks that it is needed. Calculations on placing all the beams in the same row are performed and the result showed that it is not the best way to store the beams in order to store them as close to the cutting area as possible *(see appendix 6 for calculations).*

6.2.2 First millimeter beams, then three meter beam and then six meter beams

This idea came from one of the team leaders. Since the conversion is a time consuming activity the idea involved placing the beams of the same kind next to each other. This would mean placing the millimeter beams by XX-01-XXX, the three meter beams at XX-02-XXX and the six meter beams by XX-03-XXX to make the transfer between different shelves during conversion as simple as possible. Calculations showed that this structure are not the most efficient placement which is shown in *appendix 6.*

6.2.3 Most frequent beams should be close, the rest does not matter

Another proposal from one of the production workers considering the placement of the beams was to have the most frequent beams close to the cutting area, while the rest could be placed wherever there is space available. A development of this idea was presented by our supervisor at the company, and was an idea that had been discussed within the company, was to have shelves on the cutting area with the most frequently used beams. Having shelves on the cutting area would in our opinion, based on the layout

changes that is possible, mean that there is an ability to store between 30 to 50 different kind of beams in the shelves. This depending on if the most frequent ones placed on the cutting area are beams with lengths of three or six meters. This was a proposition discussed with our supervisor as well as the senior manager, and we think that this idea is something to keep in mind.

6.2.4 Hot zone

The placement of the beams would here be based on calculations of time and distances. It is easy to understand and appreciate reasonableness from a value with the time unit seconds so that device has been used. Therefore, both distances vertically and horizontally is measured in meters that then is divided with the forklift's speed which is 1.39 m/s. This is shown in *appendix 5*. The distance is measured from the middle of the cutting area until each placement. The calculated values shows the distances from each placement to the cutting area in seconds. The beam stock takes up a larger area compared to the cutting area. This is shown in figure 6.2 below. As mentioned, the unplanned stop that contribute to waiting time tend to appear more frequent as the forklift is located closer to the inbound, packing and outbound area. Therefore, a system for applying additional time when the forklift passes a specific location is created. This specific location is henceforth called the X point, and the X point is shown in figure 6.2. We have appreciated that the transportation to the placements where the forklift need to cross the X point takes longer time. This is because the waiting time that appears, as mentioned, is related to collisions with activities linked to processes in other departments within the factory. Therefore the values in meter per seconds for each placement after the X point that is calculated based on distance in meter and the speed limit does not correspond to the time in reality. To get rid of that problem, and get a more justifying value, an additional time is added. In the first row after the X point, the row between shelf 55 and shelf 54 ten seconds is added that is supposed to correspond to the time consuming incidents that can happen along the way. In following rows, three seconds per row is added to the ten seconds because there is a greater risk that incidents will occur the longer the distance is. Thus, 13 seconds are added for the places located in the line between shelf 53 and shelf 52, the row between shelf 51 and shelf 50 have a additional time on 16 seconds and finally, the row between shelf 49 and shelf 48, the additional time is 19 seconds. This is as well shown in *appendix 5*. A map of all placements in the warehouse is developed. The map include all available placements in the warehouse and the distance to the cutting area in the unit seconds for each placement. The map is shown in *appendix 6*.

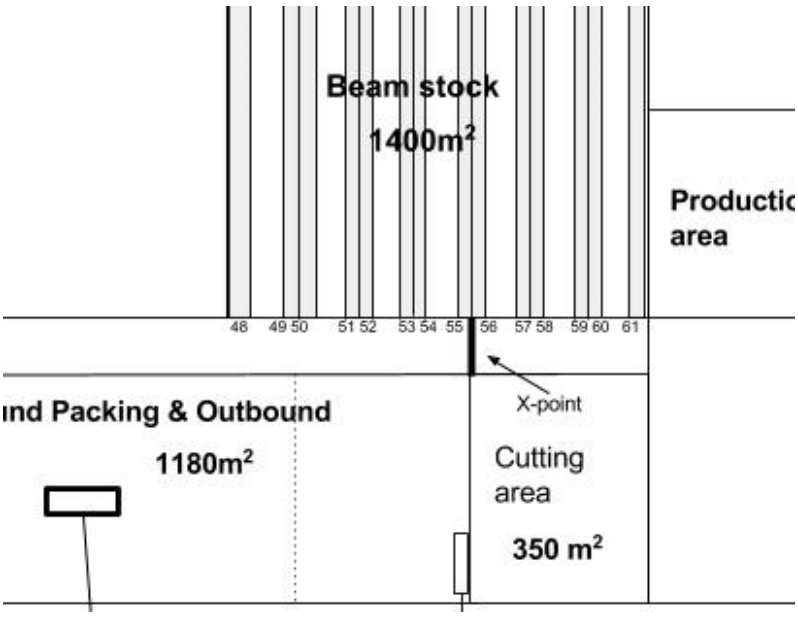

Figure 6.2: *The figure shows that the cutting area is smaller compared to the beam stock. The X point shows from which row that additional time is applied to get more reasonable values*

The placements are divided in three different zones which are zone 1, zone 2, and zone 3. The zones are shown in figure 6.3 below but a more detailed version that includes all placements within and without the hot zone is shown in *appendix 6*. The placements in zone 1, which is the dark green zone, contains the best places in consideration to that the transportation time to the cutting area is the shortest. Totally zone 1 (dark green) contains 64 placements and the time limit for the values within the zone is values

below 20 seconds. The values goes down to 13.5 seconds which is the smallest value on the map. The values in zone 2, the middle green zone, is the ones with a distance time to the cutting area that lays between 20 to 25 seconds. Zone 2 (middle green) contains 82 placements in total. It is 60 placements in zone 3, the light green zone. The values included in zone 3 (light green) is placements that have a distance time between 25 and 30 seconds to the cutting area. In all three zones it is totally 206 placements. The white area in the figure shows the placements that have a transport time above 30 seconds and therefore do not belong to the hot zone. The yellow area is the forklift's transport aisle.

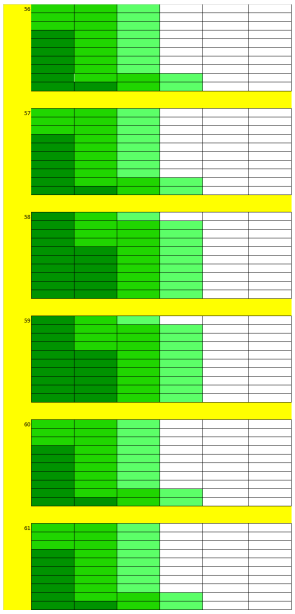

Figure 6.3: *The figure shows the hot zone that is calculated. The area contains three zones which are graded. Zone 3 (light green) is good, zone 2 (middle green) is better and zone 1 (dark green) is best.*

In order to know which beams to store in which zone, the picking activity frequency is developed. The specific frequency of each item is created using data for items sold during 2016. The accessible files include columns with CO number associated with item numbers. The file is formed so that a new CO number row appears for each new item within the order or if an item is ordered in several lengths. Therefore, both the CO numbers and item numbers can appear several time in their respective columns. In order to calculate the picking activity frequency, duplicates need to be sorted out of both columns. Therefore a new column is created in order to help with the sorting (*See appendix 7.*) The duplicates are removed using a function on the created help column. After that, a function is created that calculates how many times each CO number is associated to a specific item number and then, the list is sorted in the order of magnitude. This is shown in *appendix 8.* The item number with highest CO number hits is the item with the highest picking activity frequency and the item with the lowest picking activity frequency has the lowest CO number hits.

6.3 Layout

Several layout proposal is created and in order to sieve between the proposals, pros and cons for every solution are conducted and the weighed against each other.

6.3.1 Generally

There are some factors that will be common for all the layout proposals. Firstly one of the big cutting machines will be removed from the cutting area, this do to a non efficient use of the three big cutting machines. The operators today have the guidelines of trying to use only two of the machines and therefor we have made the evaluation that one machine can be removed. Something that will stay the same as the current state is the placement of the locker with dangerous liquids. This is due to the ventilation connected to the locker and the difficulties of moving it. The reason why the placement is questioned is on the grounds that there are a lot of other employees going to this locker and there are unnecessary movement on the cutting are by persons who do not have other reasons for being on the cutting area.

The office will also be moved on all of the layouts, this is a change is a process that has already been initiated. The placement of the office in the beginning of the cutting area is based on the access for both the production workers but also for the people who needs to use it in general. Then there is no unnecessary movements across the cutting area as well. The small rack for shorter beams has kept its placements because of the closeness to the big cutting machines. It is easily accessible for both leaving and getting material.

In addition to the picking activity frequency, there are other things to consider when placing beams. The external material like plastic material and pipes are material that could be picked by hand and should therefore have a placement on a low height and preferably near the cutting area.

6.3.2 Extra shelf

An extra six meter shelf is added, (*See figure 6.4*). This gives space to ten different kinds of six meter beams, alternatively 20 placements for three meter beams. The small cutting machine is move upward by the right wall to make space for an extra shelf. The shelf makes it possible to store between ten to 20 different items depending on the length of the beams. The placement of the shelf makes it easy to refill with new material and easy for the forklift to take out material for cutting. With this proposal we would suggest to store scrap pieces on XX-XX-010 and the most frequently used plastic material on XX-XX-020, this so the operators is able to easily get the material by hand. The shelf should be included in the hot zone, and based on the traveling time it should be part of zone 1, and therefor some of the most picked beams should be placed on the shelves on the cutting area. This layout still lacks a buffer solution, but creates more spaces in hot zone 1. A negative aspect with this layout proposal is that it might be a bit tight for the forklift to access the recycling station.

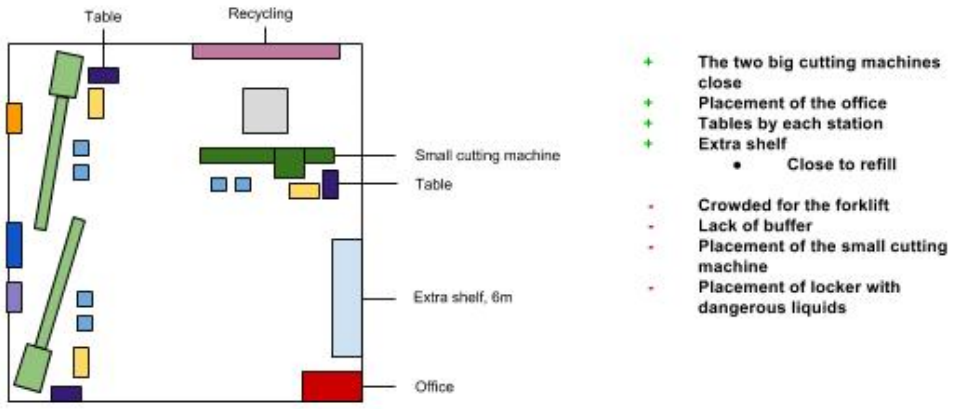

Figure 6.4: *Layout proposal with and extra shelf.*

Because of the negative aspects in the layout proposal shown in figure 6.4 above, a improved solution based on adding an extra shelf is created. The improved solution is shown in figure 6.5 below. In this solution the possible problem to access the recycling station is solved. In this solution all the components including all three cutting machines, the extra shelf as well as the recycling station has a placement close to the walls which make it easy for the forklift to access.

6.3.3 Three extra Shelves

In this layout proposal three shelves are put along side the right wall, two six meter shelves and one three meter shelf which is shown in figure 6.6. This creates between 30 and 50 extra placements, depending on if the stored beams are six or three meters long. Because of the distance all three shelves can be included in hot zone 1. This proposal does not include a buffer solution, but because of the increased number of placements in zone 1 several beams can be stored in a place closer to the cutting area. The placement of these additional shelves means that the small cutting machine needs to be moved. In this proposal the small cutting machine is placed in front of the recycling station, with enough space in between

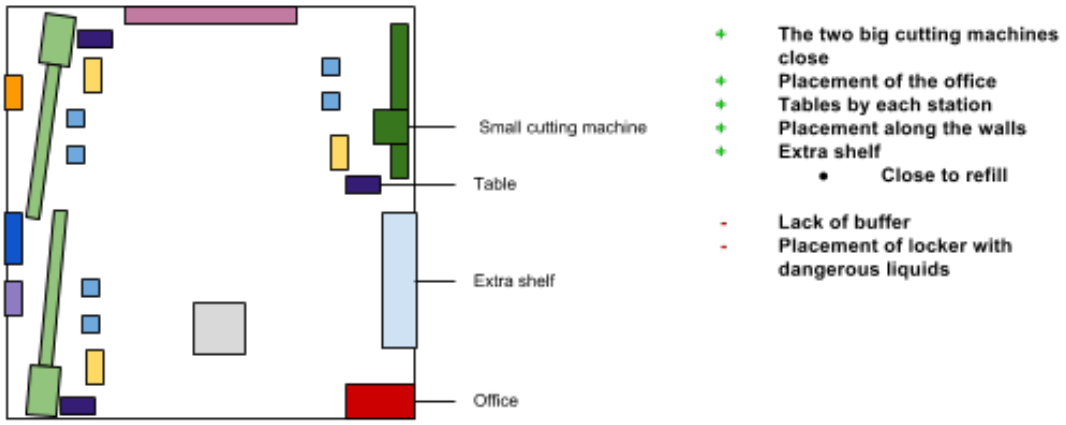

Figure 6.5: *Development of layout with extra shelf.*

for the forklift to be able to pick up the containers to empty them. This is also done to keep all the recycling containers in the same place. This placement of the machine creates a few difficulties. Firstly the movement of the forklift will be less smooth in comparison to the current layout when emptying the recycling bins. It may also create difficulties when taking material in and out from the shelf furthest down the cutting area.

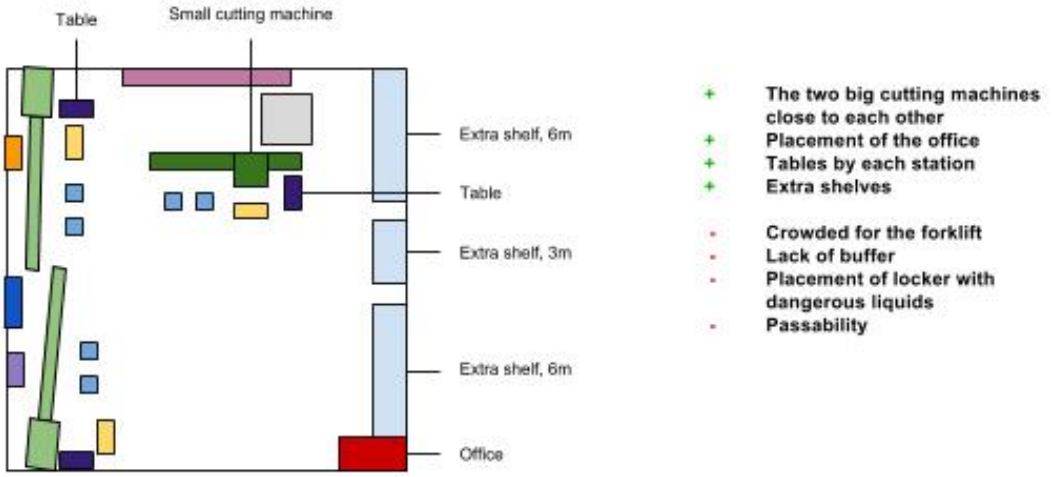

Figure 6.6: *Layout proposal with three additional shelves.*

Another solution with three extra shelves is shown in figure 6.7. The small cutting machine has been moved to the wall furthest down the cutting area. This placement has made it necessary to split the different recycling bins into three different sections. These are placed in east access spots in the factory. This solution makes it easy to take material in and out of the shelves and there is a lot of space for the forklift to move around. There might be a risk of the space being to crowded around the walls and that the space is not utilized enough.

Figure 6.7: *Layout proposal with three additional shelves.*

An other option would be to have the recycling in the middle of the cutting area. (*See figure 6.8*). In addition to what have been mentioned above this development of the proposal makes the recycling bins stand together, but is still easy to access for both the operators and the forklift driver. A con with this placement is that the recycling bins might make the forklift drive a small detour from the shelves on the cutting area to access the big cutting machines.

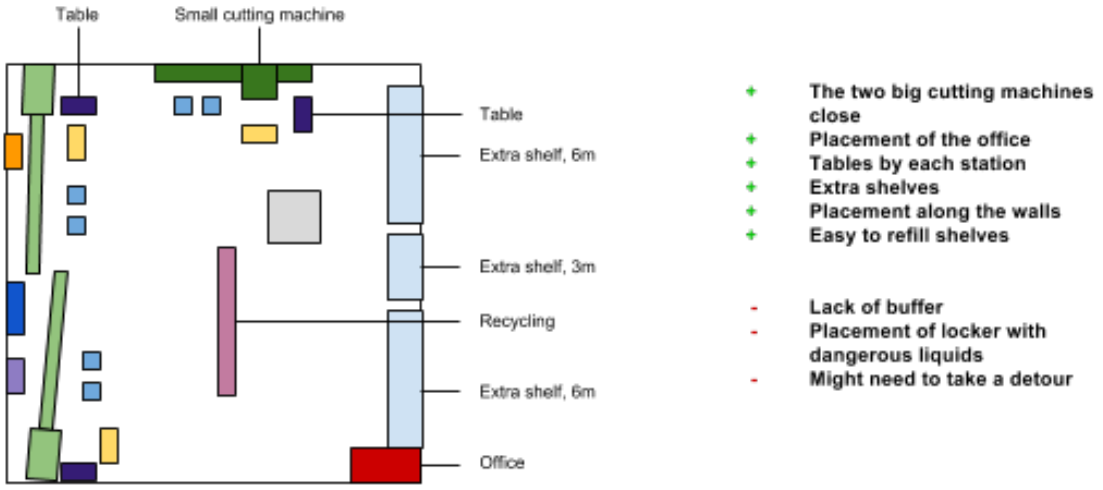

Figure 6.8: *Layout proposal with three additional shelves.*

6.3.4 Buffer

One of the main problem is the lack of buffer and therefor we spent time trying to find a buffer solution for the company that would be a reasonable investment. Most buffer solutions that are on the market are adapted to smaller items and therefore not applicable on the company. We therefor tried to create our own solutions. The first idea was to put wheels on the existing unloading stations, something that was later mentioned by one of the operators as a buffer solution. We discussed this solution with the senior manager, and it had apparently been tried in the factory earlier. The solution worked with lighter material, but as soon as the heavier beams was placed on the unloading station it was unmovable by hand. Several of our buffer proposals were made in different levels both in height and width, but the recurring problem was that there was no way to both be able to refill and remove the material smoothly and at the same time be easily accessed for the operator. Therefor the conclusion was drawn to that it needs to be some kind of rotating system. For that we thought about to create a wheel formation with four shelves that moved in quarters. Since the ability to built functional solutions was seen around factory we thought that this could be built by the material available in the factory. We discussed this solution with our supervisors and the conclusion became that once again the weight would be a problem for such a simple solution.

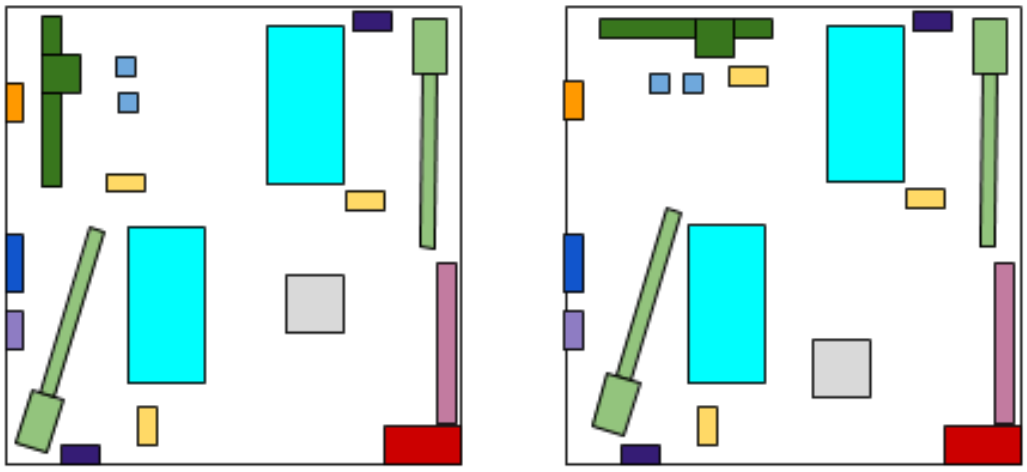

Figure 6.9: *Layout proposals with our buffer solution.*

6.3.5 Automatic storage

The automatic disbatch machine that was mentioned in section 4.4 was during a our visit up for discussion between the managers. A proposal was then to have two of these disbatch machines. The thought was then that one would be storage for the most frequent beams while the other one would be used as a buffer for the production for the following hours. This would mean that the one preparing the orders could load the buffer machine with the material that should be used for the the next hours.

A layout proposal with this solution was showed by the senior manager. (*See figure 6.10*). This solution would not be possible with the current placement of the beam stock and the cutting area and therefor a restructuring of the layout surface would need to be done. If the structure of the machine would be the same as discussed in section 4.4, with two pocket of each beam kind, there would be a total of 30 placements available. But since the arrangement was to have one machine as storage and one as buffer it would be reasonable to have a different arrangement in the buffer. The buffer would be refilled during the day with beams, in addition to those stored in the other machine, on upcoming orders.

6.4 Influencing factors

Beyond the focus areas of the study there are some other parameters that contributes to improvement of the efficiency. As mentioned, the Hawthorne studies performed av Elton May among others showed

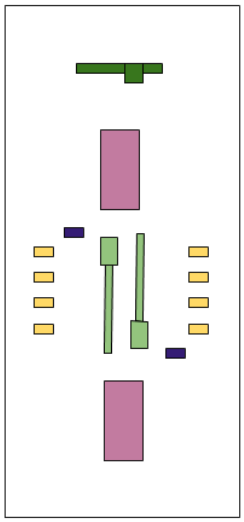

Figure 6.10: *Layout proposal with two automatic disbatch machines.*

that employees appreciated attention and that interest in the employees and their working conditions is a human factor that improves the efficiency. To involve the production workers in development and decisions is a positive impact on the efficiency. The implementation of Kaizen, a method used for constantly improving process with small changes, is appreciated by the production workers. They can give concrete proposals on improvement in a forum where it can be captured. During our conversations with the production workers they expressed a willing to contribute with improvements. The production workers have a work pride and feel a responsibility for the production which makes them work diligent. From the management perspective, a positive attitude towards working with Kaizen was also expressed. According to the warehouse manager, the production workers are the ones who knows the production processes the best because they are performing them each day and therefore their opinion should be heard. That it is important to have good contact between the management and the production workers, which was improved after implementing Kaizen is also mediated. The attitude about employee involvement within Beam Producer AB is an important part that we ensure them to continue to maintain and improve. A positive and active participation between the employees and the management contributes to active development of production and processes. To use Kaizen increases the communication opportunities for improvement solutions because there is a standard way to convey the ideas.

In addition to the picking activity frequency, there are other things to consider when placing beams. The external material like plastic material and pipes are material that could be picked by hand and should therefore have a placement on a low height and preferably near the cutting area.

6.5 Future work

Some future work that we think would be suitable to do at the company is to look over their assortment of beams. During the study it has been noted that there are several beams stored that has low picking frequency and generally have small order quantities and turnover rate. The references can only be done to the years of 2016, but the recommendation based on made observations would be for the company to decommission some of the beams in their assortment. This is an opening to develop their assortment to what the market will be using in the future.

We noticed a lot of safety guidelines within the cutting area that were not applied. For example by every cutting machine there was a sign instructing to use protective glasses when using the machine. Non of the operators used safety glasses and we never saw a place where the operators could go and get a pair. We think this is a problem since we saw a lot of tiles sprinkled while the cutting machine was in use. Since we are not familiar with the guidelines for working conditions in the country in question this might be more of a recommendation than a instruction.

The company should put time in planning on how they can use their resources to the fullest. There is an opportunity in using the big cutting machines more automated, but the computer programs that are

used today is not easily synced with the machines. There is a project of using a program to reduce the scrap material, but right now our perception is that it takes a lot of time that makes the work inefficient. If the company would would be able to take time to sync their resources and educate their employees in the systems it could have a huge effect on the efficiency and smoothness of the everyday business.

7 Conclusion

The conclusions presented below is based on the theories of placement within zones aswell as SLP. The empirical studies have played a big part in the final conclusions due to making them as implementable as possible.

Our recommendation to Beam Producer AB is to implement a hot zone. The placement of beams within the hot zone should not be fixed but movable. The high frequently used beams should be placed in zone 1 of the hot zone in order to minimize the total handling work that in turn would minimize the handling time. Some of the items are used notedly more frequent than other and therefore, it can be good to have a fixed location on those beams to make sure that they always have a placement with shortest possible distance from the cutting area so the handling time is minimized to the fullest. The most frequently used beam's current placement gives a the total transportation time on 13.9 h per year and with a placement in the hot zone the time could be minimized to 5.6 h per year. It is a reduction on 8.3 h per year which corresponds to a time reduction of 61% per year (*See appendix 9 for calculations*). Another high frequency used beam already had a placement in our hot zone which means that we cannot reduce any time for that particular item. However, noteworthy is that during current moveable placement, it is not a guarantee that the beam always have such good placement so to store this item in a hot zone would be good anyway.

Several of the employees mentioned the big problem with conversion, and we have taken this in consideration when making our proposal for storing. We have created a hot zone for pieces based on a suitable starting point, and this do not collide with the hot zone for millimeters. We have not found a suitable method to make the conversion simpler then it is today since the process is so reactive.

In combination with implementing a hot zone, our recommendation of the layout formation is the developed proposal including three extra shelves. When summing up the important factors this layout get the predominant best result and and we judge that it would be applicable in the cutting area without any bigger difficulties. The split of recycling is something that we do not see as a problem. The operators needs to go to the recycling bins several times with different material and since the distance to all bins are about the same that is not a influencing factor. Within the layout proposal zone 1 in the hot zone would get between 30 and 50 new placements depending on if beams in three or six meters were to be stored. Cost wise this proposal is a relatively small investment, it will take time to rearrange and new shelves will need to be bought but otherwise it is based on the already existing resources.

Regarding the organization of small beams that can be reused instead of becoming scrap we had the thought of doing some kind of system so that the operator could be enlightened of its existence in the rack for shorter beams. But in the end we could not see a more efficient way then the solution that is used today. Since the operators has such track on which items that are typically placed there it is more efficient to go to the shelf and look rather then to go to look in a computer system. This might change if the production would registrate their items in another way.

If the company were to be doing an investment we would recommend to do it in hiring another person for the cutting area. As we interpret it would be best suited for shift A, the shift with three main persons. It would reduce the workload as well as creating a safety when people are sick or away for other reasons. We noticed that it was very stressful when one of the production workers was away from work during our visit. If the distribution of workers would change, this is a flexible investment that could be moved to other parts of the company, while for example a machine is a fixed investment that can not be used in other parts of the production.

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A Appendix

Appendix 1

Calculations is shown for average cutting time and average mean time

	Cutting machine 1, morning (sec)	Cutting machine 2, morning (sec)	Cutting machine 2, evening (sec)	Cutting machine 1, evening (sec)
Cutting time	21,2	20,9	24,6	21,8
Mean time	54,5	182,9	9,9	39,8
Cutting time	39,3	21,7	26,3	31,8
Mean time	32,8	112,8	12,8	40,6
Cutting time	19,7	15,9	20,6	33,9
Mean time	28,7	11,5	13,3	9,1
Cutting time	13,6	20,8	23,3	14,2
Mean time		22,9	10,2	
Cutting time	14,8	21,1	24,7	
Mean time	32,4	31,9	8,9	
Cutting time	15	20,3	26,9	
Mean time	16,7	385		
Cutting time	13,9	24,5		
Mean time	16,2	14,1		
Cutting time	14,2	24,5		
Mean time	36,8	15,8		
Cutting time	13,6	20,2		
Mean time	8,8	74,2		
Cutting time	13,6	21,4		
Mean time	8,8			
Cutting time	13,3	25,8		
Mean time	7,5	26,3		
Cutting time	13	21		
Mean time	9,6	10,6		
Cutting time	10,4	15		
Mean time	29,2	28,6		
Cutting time	22,8	48,6		
Mean time	51,2	13,6		
Cutting time	14,2	38,7		
Mean time	5,9	28,8		
Cutting time	15,8	34,4		
Mean time	32,2	231,7		
Cutting time	14,9			
Mean time	7			
Cutting time	16,3			

Average cutting time	16,6	24,1	24,4	25,4

Average mean time	22,2	79,4	11,1	29,8

Total average cutting time	22,7

Total aveage mean time	35,6

Appendix 2

Questions before departure

- ls there a reason for different placements of certain products? Why have the same product in different rows? (Is it because you pick up other products from the same row at the same time?)
- Is there a standard method that should be used? And in that case does everyone use the standard or do they create their own way to execute the work?
- What is the height, length and width of the storage units?
- (We know it's 1400 m^2, but we wonder how big the shelves are)
- How do you handle the fast pase of information? Getting an order one day and be able to deliver the next.
- What developing projects have been performed the past years? Our supervisor mentioned that a lot of projects have been started, but not completed, how come? Is it because lack of resources or are there other factors?
- Is there any row, shelf and/or pocket that is easier to pick up material from? We have noticed that a lot of the frequent used beams are stored in shelf 01, and pocket 040-060. Is there a reason for this placement?
- If several different beams are stored in the same pocket, do you have to move the beam that is further out to reach the beam in the back? Is there a system for that?
- We can't find the beams with item number QRST and UVXY on the map of the beams location. Where do you store these beams?

Appendix 3

Notes from each day in the factory

Day 1:

Arrived at the factory at 13:30, met the senior manager who gave us a short tour of the factory. We then sat down with the senior manager, warehouse manager and our supervisor to make up a plan for the following days. We then had about 1,5 hours to look in the factory by ourselves. When we stood by the cutting area we mainly observed one worker and his work process.

Questions that appeared when we observed the processes:

- Which weight does the heaviest beam have?
- Stickers, should they be on every beam that is cut or are there other guidelines?
- Number of items per order? How much do they differ between each other?
- Guidelines for every work station
    - How big of a surface?
    - What is demanded to be on every station?
- CNC machine - How is the drilling process involved in the main cutting process?
- How accurate are the excel placements? Are they what you strive for or are they taken from a specific time point?

Day 2:

Arrived at the factory at 7:20, went to the warehouse manager's office that became our temporary workspace during the visit. We had a meeting where the warehouse manager explained the different kind of orders (CO's, MO's and DO's). Our employee contact arrived who was supposed to guide us during the day and the rest of the visit. We got a short tour of the departments in the factory, was showed how the packing is done was shown and then we looked at the storage and the questions that we had about the storage from earlier was discussed. The rest of the day we stood by the cutting area, took times and observed the processes. During this day, each production worker was responsible for the whole process themselves so one production worker both drove the forklift, handled the cutting machine and did the work in the office. We went back to our temporary workspace several times during the day to discuss what we had seen and to transcribe our notes. Our employee contact was available to answer questions all day.

Day 3:

Arrived at the factor at 7:30 and went out measuring times for both the cutting process and the forklift. Today, the processes were different in such way that the production workers worked as a team. They had one person responsible for driving the forklift and the other two persons were responsible for each cutting machine. This way of working is a part of a new method that the company temporary introduced in order to get the processes more efficient. We also measured the distance on different places in the production. Some steps of the processes that we thought we understood yesterday was a bit different today, so we got a bigger picture on how the processes work together and also how they can vary. Most of the day were spent talking to the team leaders, our

employee contact, the warehouse manager and the production workers. This was done in order to get their opinion on how the processes works today and how they can improved. We also started discussing different solutions with each other and some of the ideas we also discussed with our employee contact.

Questions that we asked the team leaders, production workers, the warehouse manager and our employee contact:

- What do you think about the new method?
    - What is the responsibilities for the forklift driver/the one handling the machine?
    - Is it hard to manage to drive the forklift/handle the machine or do you have time to do something else?
- What problems do you see within the cutting process?
- What problems do you see with the beam stock?
- What do you want to change in the factory?
- Do you have some ideas on how to store the beams?
- If the only limitation was the space, what would you like to do about the layout? How would your perfect layout look like? And with what functions?

Day 4:

Arrived at the factory at 7.30. Today we had listed what we needed to do in the factory before we went back home so we started to go through the list as soon as we arrived. We measured some more times on the forklift and some more times on the cutting process and made sure that we had documented the factory visually by pictures and movies in order to be able to check things associated to the factory later on during the study. We continued to talk to the team leaders, our employee contact, the warehouse manager, the production workers and we also got the opportunity to talk the the senior manager. We used the same questions as yesterday.

Appendix 4

Calculations is shown for the forklifts speed

Forklift	Distance (m)	Time (sec)	Speed (m/s)	Speed (km/h)
Horizontally				
51-01-10 -> Middle	41,3	36,1	1,14	4,12
Middle -> 59.01.010	18,8	9,4	2,00	7,20
59.01.010 -> middle	18,8	10,1	1,86	6,70
Total	**78,9**	**55,6**	**1,42**	**5,11**

Vertically with material	Distance (m)	Time (sec)	Speed (m/s)	Speed (km/h)
Height with material 090->010	5,8	11,2	0,52	1,86
Height with material 100->010	6,5	16	0,41	1,46
Height with material 070->020	3,5	7,8	0,45	1,62
Total	**15,8**	**35**	**0,45**	**1,63**

Vertically without material	Distance (m)	Time (sec)	Speed (m/s)	Speed (km/h)
Height without material 010->100	6,5	6,7	0,97	3,49
Height 100->10	6,5	13,7	0,47	1,71
Height without material 10->100	6,5	14,1	0,46	1,66
Total	**19,5**	**34,5**	**0,57**	**2,03**

Depth with material (on the racks)	Distance (m)	Time (sec)	Speed (m/s)	Speed (km/h)
Depth (with material)	1,03	7,5	0,14	0,49
Depth (with material)	1,03	6,8	0,15	0,55
Depth (with material)	1,03	11,7	0,09	0,32
Total	**3,09**	**26**	**0,12**	**0,43**

Depth without material (on the racks)	Distance (m)	Time (sec)	Speed (m/s)	Speed (km/h)
Depth (without material)	1,03	2,2	0,47	1,69
Depth (without material)	1,03	7,2	0,14	0,52
Total	**2,06**	**9,4**	**0,22**	**0,79**

Appendix 5

Calculations of total time from each placement to the cutting area and additional times is shown

Placement	Distance horizontally (m)	Distance verically (m)	Total distance (m)	Total time (sec)	Additional time (sec)	Total time, additonal time included (sec)
61-01-010	23,3	0	23,3	16,76259	0	16,8
61-01-020	23,3	0,9	24,2	17,410072	0	17,4
61-01-030	23,3	1,6	24,9	17,913669	0	17,9
61-01-040	23,3	2,3	25,6	18,417266	0	18,4
61-01-050	23,3	3	26,3	18,920863	0	18,9
61-01-060	23,3	3,7	27	19,42446	0	19,4
61-01-070	23,3	4,4	27,7	19,928058	0	19,9
61-01-080	23,3	5,1	28,4	20,431655	0	20,4
61-01-090	23,3	5,8	29,1	20,935252	0	20,9
61-01-100	23,3	6,5	29,8	21,438849	0	21,4
61-02-010	27,8	0	27,8	20	0	20
61-02-020	27,8	0,9	28,7	20,647482	0	20,6
61-02-030	27,8	1,6	29,4	21,151079	0	21,2
61-02-040	27,8	2,3	30,1	21,654676	0	21,7
61-02-050	27,8	3	30,8	22,158273	0	22,2
61-02-060	27,8	3,7	31,5	22,661871	0	22,7
61-02-070	27,8	4,4	32,2	23,165468	0	23,2
61-02-080	27,8	5,1	32,9	23,669065	0	23,7
61-02-090	27,8	5,8	33,6	24,172662	0	24,2
61-02-100	27,8	6,5	34,3	24,676259	0	24,7
61-03-010	33,8	0	33,8	24,316547	0	24,3
61-03-020	33,8	0,9	34,7	24,964029	0	25
61-03-030	33,8	1,6	35,4	25,467626	0	25,5
61-03-040	33,8	2,3	36,1	25,971223	0	26
61-03-050	33,8	3	36,8	26,47482	0	26,5
61-03-060	33,8	3,7	37,5	26,978417	0	27
61-03-070	33,8	4,4	38,2	27,482014	0	27,5
61-03-080	33,8	5,1	38,9	27,985612	0	28
61-03-090	33,8	5,8	39,6	28,489209	0	28,5
61-03-100	33,8	6,5	40,3	28,992806	0	29
61-04-010	40,5	0	40,5	29,136691	0	29,1
61-04-020	40,5	0,9	41,4	29,784173	0	29,8
61-04-030	40,5	1,6	42,1	30,28777	0	30,3
61-04-040	40,5	2,3	42,8	30,791367	0	30,8
61-04-050	40,5	3	43,5	31,294964	0	31,3
61-04-060	40,5	3,7	44,2	31,798561	0	31,8
61-04-070	40,5	4,4	44,9	32,302158	0	32,3
61-04-080	40,5	5,1	45,6	32,805755	0	32,8
61-04-090	40,5	5,8	46,3	33,309353	0	33,3
61-04-100	40,5	6,5	47	33,81295	0	33,8
61-05-010	47,3	0	47,3	34,028777	0	34
61-05-020	47,3	0,9	48,2	34,676259	0	34,7

61-05-030	47,3	1,6	48,9	35,179856	0	35,2
61-05-040	47,3	2,3	49,6	35,683453	0	35,7
61-05-050	47,3	3	50,3	36,18705	0	36,2
61-05-060	47,3	3,7	51	36,690647	0	36,7
61-05-070	47,3	4,4	51,7	37,194245	0	37,2
61-05-080	47,3	5,1	52,4	37,697842	0	37,7
61-05-090	47,3	5,8	53,1	38,201439	0	38,2
61-05-100	47,3	6,5	53,8	38,705036	0	38,7
61-06-010	53,3	0	53,3	38,345324	0	38,3
61-06-020	53,3	0,9	54,2	38,992806	0	39
61-06-030	53,3	1,6	54,9	39,496403	0	39,5
61-06-040	53,3	2,3	55,6	40	0	40
61-06-050	53,3	3	56,3	40,503597	0	40,5
61-06-060	53,3	3,7	57	41,007194	0	41
61-06-070	53,3	4,4	57,7	41,510791	0	41,5
61-06-080	53,3	5,1	58,4	42,014388	0	42
61-06-090	53,3	5,8	59,1	42,517986	0	42,5
61-06-100	53,3	6,5	59,8	43,021583	0	43
60-01-010	23,3	0	23,3	16,76259	0	16,8
60-01-020	23,3	0,9	24,2	17,410072	0	17,4
60-01-030	23,3	1,6	24,9	17,913669	0	17,9
60-01-040	23,3	2,3	25,6	18,417266	0	18,4
60-01-050	23,3	3	26,3	18,920863	0	18,9
60-01-060	23,3	3,7	27	19,42446	0	19,4
60-01-070	23,3	4,4	27,7	19,928058	0	19,9
60-01-080	23,3	5,1	28,4	20,431655	0	20,4
60-01-090	23,3	5,8	29,1	20,935252	0	20,9
60-01-100	23,3	6,5	29,8	21,438849	0	21,4
60-02-010	27,8	0	27,8	20	0	20
60-02-020	27,8	0,9	28,7	20,647482	0	20,6
60-02-030	27,8	1,6	29,4	21,151079	0	21,2
60-02-040	27,8	2,3	30,1	21,654676	0	21,7
60-02-050	27,8	3	30,8	22,158273	0	22,2
60-02-060	27,8	3,7	31,5	22,661871	0	22,7
60-02-070	27,8	4,4	32,2	23,165468	0	23,2
60-02-080	27,8	5,1	32,9	23,669065	0	23,7
60-02-090	27,8	5,8	33,6	24,172662	0	24,2
60-02-100	27,8	6,5	34,3	24,676259	0	24,7
60-03-010	33,8	0	33,8	24,316547	0	24,3
60-03-020	33,8	0,9	34,7	24,964029	0	25
60-03-030	33,8	1,6	35,4	25,467626	0	25,5
60-03-040	33,8	2,3	36,1	25,971223	0	26
60-03-050	33,8	3	36,8	26,47482	0	26,5
60-03-060	33,8	3,7	37,5	26,978417	0	27
60-03-070	33,8	4,4	38,2	27,482014	0	27,5
60-03-080	33,8	5,1	38,9	27,985612	0	28
60-03-090	33,8	5,8	39,6	28,489209	0	28,5
60-03-100	33,8	6,5	40,3	28,992806	0	29
60-04-010	40,5	0	40,5	29,136691	0	29,1
60-04-020	40,5	0,9	41,4	29,784173	0	29,8

60-04-030	40,5	1,6	42,1	30,28777	0	30,3
60-04-040	40,5	2,3	42,8	30,791367	0	30,8
60-04-050	40,5	3	43,5	31,294964	0	31,3
60-04-060	40,5	3,7	44,2	31,798561	0	31,8
60-04-070	40,5	4,4	44,9	32,302158	0	32,3
60-04-080	40,5	5,1	45,6	32,805755	0	32,8
60-04-090	40,5	5,8	46,3	33,309353	0	33,3
60-04-100	40,5	6,5	47	33,81295	0	33,8
60-05-010	47,3	0	47,3	34,028777	0	34
60-05-020	47,3	0,9	48,2	34,676259	0	34,7
60-05-030	47,3	1,6	48,9	35,179856	0	35,2
60-05-040	47,3	2,3	49,6	35,683453	0	35,7
60-05-050	47,3	3	50,3	36,18705	0	36,2
60-05-060	47,3	3,7	51	36,690647	0	36,7
60-05-070	47,3	4,4	51,7	37,194245	0	37,2
60-05-080	47,3	5,1	52,4	37,697842	0	37,7
60-05-090	47,3	5,8	53,1	38,201439	0	38,2
60-05-100	47,3	6,5	53,8	38,705036	0	38,7
60-06-010	53,3	0	53,3	38,345324	0	38,3
60-06-020	53,3	0,9	54,2	38,992806	0	39
60-06-030	53,3	1,6	54,9	39,496403	0	39,5
60-06-040	53,3	2,3	55,6	40	0	40
60-06-050	53,3	3	56,3	40,503597	0	40,5
60-06-060	53,3	3,7	57	41,007194	0	41
60-06-070	53,3	4,4	57,7	41,510791	0	41,5
59-01-010	18,8	0	18,8	13,52518	0	13,5
59-01-020	18,8	0,9	19,7	14,172662	0	14,2
59-01-030	18,8	1,6	20,4	14,676259	0	14,7
59-01-040	18,8	2,3	21,1	15,179856	0	15,2
59-01-050	18,8	3	21,8	15,683453	0	15,7
59-01-060	18,8	3,7	22,5	16,18705	0	16,2
59-01-070	18,8	4,4	23,2	16,690647	0	16,7
59-01-080	18,8	5,1	23,9	17,194245	0	17,2
59-01-090	18,8	5,8	24,6	17,697842	0	17,7
59-01-100	18,8	6,5	25,3	18,201439	0	18,2
59-02-010	24	0	24	17,266187	0	17,3
59-02-020	24	0,9	24,9	17,913669	0	17,9
59-02-030	24	1,6	25,6	18,417266	0	18,4
59-02-040	24	2,3	26,3	18,920863	0	18,9
59-02-050	24	3	27	19,42446	0	19,4
59-02-060	24	3,7	27,7	19,928058	0	19,9
59-02-070	24	4,4	28,4	20,431655	0	20,4
59-02-080	24	5,1	29,1	20,935252	0	20,9
59-02-090	24	5,8	29,8	21,438849	0	21,4
59-02-100	24	6,5	30,5	21,942446	0	21,9
59-03-010	28,5	0	28,5	20,503597	0	20,5
59-03-020	28,5	0,9	29,4	21,151079	0	21,2
59-03-030	28,5	1,6	30,1	21,654676	0	21,7
59-03-040	28,5	2,3	30,8	22,158273	0	22,2
59-03-050	28,5	3	31,5	22,661871	0	22,7

59-03-060	28,5	3,7	32,2	23,165468	0	23,2
59-03-070	28,5	4,4	32,9	23,669065	0	23,7
59-03-080	28,5	5,1	33,6	24,172662	0	24,2
59-03-090	28,5	5,8	34,3	24,676259	0	24,7
59-03-100	28,5	6,5	35	25,179856	0	25,2
59-04-010	35,3	0	35,3	25,395683	0	25,4
59-04-020	35,3	0,9	36,2	26,043165	0	26
59-04-030	35,3	1,6	36,9	26,546763	0	26,5
59-04-040	35,3	2,3	37,6	27,05036	0	27,1
59-04-050	35,3	3	38,3	27,553957	0	27,6
59-04-060	35,3	3,7	39	28,057554	0	28,1
59-04-070	35,3	4,4	39,7	28,561151	0	28,6
59-04-080	35,3	5,1	40,4	29,064748	0	29,1
59-04-090	35,3	5,8	41,1	29,568345	0	29,6
59-04-100	35,3	6,5	41,8	30,071942	0	30,1
59-05-010	42	0	42	30,215827	0	30,2
59-05-020	42	0,9	42,9	30,863309	0	30,9
59-05-030	42	1,6	43,6	31,366906	0	31,4
59-05-040	42	2,3	44,3	31,870504	0	31,9
59-05-050	42	3	45	32,374101	0	32,4
59-05-060	42	3,7	45,7	32,877698	0	32,9
59-05-070	42	4,4	46,4	33,381295	0	33,4
59-05-080	42	5,1	47,1	33,884892	0	33,9
59-05-090	42	5,8	47,8	34,388489	0	34,4
59-05-100	42	6,5	48,5	34,892086	0	34,9
59-06-010	48	0	48	34,532374	0	34,5
59-06-020	48	0,9	48,9	35,179856	0	35,2
59-06-030	48	1,6	49,6	35,683453	0	35,7
59-06-040	48	2,3	50,3	36,18705	0	36,2
59-06-050	48	3	51	36,690647	0	36,7
59-06-060	48	3,7	51,7	37,194245	0	37,2
59-06-070	48	4,4	52,4	37,697842	0	37,7
58-01-010	18,8	0	18,8	13,52518	0	13,5
58-01-020	18,8	0,9	19,7	14,172662	0	14,2
58-01-030	18,8	1,6	20,4	14,676259	0	14,7
58-01-040	18,8	2,3	21,1	15,179856	0	15,2
58-01-050	18,8	3	21,8	15,683453	0	15,7
58-01-060	18,8	3,7	22,5	16,18705	0	16,2
58-01-070	18,8	4,4	23,2	16,690647	0	16,7
58-01-080	18,8	5,1	23,9	17,194245	0	17,2
58-01-090	18,8	5,8	24,6	17,697842	0	17,7
58-01-100	18,8	6,5	25,3	18,201439	0	18,2
58-02-010	24	0	24	17,266187	0	17,3
58-02-020	24	0,9	24,9	17,913669	0	17,9
58-02-030	24	1,6	25,6	18,417266	0	18,4
58-02-040	24	2,3	26,3	18,920863	0	18,9
58-02-050	24	3	27	19,42446	0	19,4
58-02-060	24	3,7	27,7	19,928058	0	19,9
58-02-070	24	4,4	28,4	20,431655	0	20,4
58-02-080	24	5,1	29,1	20,935252	0	20,9

58-02-090	24	5,8	29,8	21,438849	0	21,4
58-02-100	24	6,5	30,5	21,942446	0	21,9
58-03-010	28,5	0	28,5	20,503597	0	20,5
58-03-020	28,5	0,9	29,4	21,151079	0	21,2
58-03-030	28,5	1,6	30,1	21,654676	0	21,7
58-03-040	28,5	2,3	30,8	22,158273	0	22,2
58-03-050	28,5	3	31,5	22,661871	0	22,7
58-03-060	28,5	3,7	32,2	23,165468	0	23,2
58-03-070	28,5	4,4	32,9	23,669065	0	23,7
58-03-080	28,5	5,1	33,6	24,172662	0	24,2
58-03-090	28,5	5,8	34,3	24,676259	0	24,7
58-03-100	28,5	6,5	35	25,179856	0	25,2
58-04-010	35,3	0	35,3	25,395683	0	25,4
58-04-020	35,3	0,9	36,2	26,043165	0	26
58-04-030	35,3	1,6	36,9	26,546763	0	26,5
58-04-040	35,3	2,3	37,6	27,05036	0	27,1
58-04-050	35,3	3	38,3	27,553957	0	27,6
58-04-060	35,3	3,7	39	28,057554	0	28,1
58-04-070	35,3	4,4	39,7	28,561151	0	28,6
58-04-080	35,3	5,1	40,4	29,064748	0	29,1
58-04-090	35,3	5,8	41,1	29,568345	0	29,6
58-04-100	35,3	6,5	41,8	30,071942	0	30,1
58-05-010	42	0	42	30,215827	0	30,2
58-05-020	42	0,9	42,9	30,863309	0	30,9
58-05-030	42	1,6	43,6	31,366906	0	31,4
58-05-040	42	2,3	44,3	31,870504	0	31,9
58-05-050	42	3	45	32,374101	0	32,4
58-05-060	42	3,7	45,7	32,877698	0	32,9
58-05-070	42	4,4	46,4	33,381295	0	33,4
58-05-080	42	5,1	47,1	33,884892	0	33,9
58-05-090	42	5,8	47,8	34,388489	0	34,4
58-05-100	42	6,5	48,5	34,892086	0	34,9
58-06-010	48	0	48	34,532374	0	34,5
58-06-020	48	0,9	48,9	35,179856	0	35,2
58-06-030	48	1,6	49,6	35,683453	0	35,7
58-06-040	48	2,3	50,3	36,18705	0	36,2
58-06-050	48	3	51	36,690647	0	36,7
58-06-060	48	3,7	51,7	37,194245	0	37,2
58-06-070	48	4,4	52,4	37,697842	0	37,7
57-01-010	23,3	0	23,3	16,76259	0	16,8
57-01-020	23,3	0,9	24,2	17,410072	0	17,4
57-01-030	23,3	1,6	24,9	17,913669	0	17,9
57-01-040	23,3	2,3	25,6	18,417266	0	18,4
57-01-050	23,3	3	26,3	18,920863	0	18,9
57-01-060	23,3	3,7	27	19,42446	0	19,4
57-01-070	23,3	4,4	27,7	19,928058	0	19,9
57-01-080	23,3	5,1	28,4	20,431655	0	20,4
57-01-090	23,3	5,8	29,1	20,935252	0	20,9
57-01-100	23,3	6,5	29,8	21,438849	0	21,4
57-02-010	27,8	0	27,8	20	0	20

57-02-020	27,8	0,9	28,7	20,647482	0	20,6
57-02-030	27,8	1,6	29,4	21,151079	0	21,2
57-02-040	27,8	2,3	30,1	21,654676	0	21,7
57-02-050	27,8	3	30,8	22,158273	0	22,2
57-02-060	27,8	3,7	31,5	22,661871	0	22,7
57-02-070	27,8	4,4	32,2	23,165468	0	23,2
57-02-080	27,8	5,1	32,9	23,669065	0	23,7
57-02-090	27,8	5,8	33,6	24,172662	0	24,2
57-02-100	27,8	6,5	34,3	24,676259	0	24,7
57-03-010	33,8	0	33,8	24,316547	0	24,3
57-03-020	33,8	0,9	34,7	24,964029	0	25
57-03-030	33,8	1,6	35,4	25,467626	0	25,5
57-03-040	33,8	2,3	36,1	25,971223	0	26
57-03-050	33,8	3	36,8	26,47482	0	26,5
57-03-060	33,8	3,7	37,5	26,978417	0	27
57-03-070	33,8	4,4	38,2	27,482014	0	27,5
57-03-080	33,8	5,1	38,9	27,985612	0	28
57-03-090	33,8	5,8	39,6	28,489209	0	28,5
57-03-100	33,8	6,5	40,3	28,992806	0	29
57-04-010	40,5	0	40,5	29,136691	0	29,1
57-04-020	40,5	0,9	41,4	29,784173	0	29,8
57-04-030	40,5	1,6	42,1	30,28777	0	30,3
57-04-040	40,5	2,3	42,8	30,791367	0	30,8
57-04-050	40,5	3	43,5	31,294964	0	31,3
57-04-060	40,5	3,7	44,2	31,798561	0	31,8
57-04-070	40,5	4,4	44,9	32,302158	0	32,3
57-04-080	40,5	5,1	45,6	32,805755	0	32,8
57-04-090	40,5	5,8	46,3	33,309353	0	33,3
57-04-100	40,5	6,5	47	33,81295	0	33,8
57-05-010	47,3	0	47,3	34,028777	0	34
57-05-020	47,3	0,9	48,2	34,676259	0	34,7
57-05-030	47,3	1,6	48,9	35,179856	0	35,2
57-05-040	47,3	2,3	49,6	35,683453	0	35,7
57-05-050	47,3	3	50,3	36,18705	0	36,2
57-05-060	47,3	3,7	51	36,690647	0	36,7
57-05-070	47,3	4,4	51,7	37,194245	0	37,2
57-05-080	47,3	5,1	52,4	37,697842	0	37,7
57-05-090	47,3	5,8	53,1	38,201439	0	38,2
57-05-100	47,3	6,5	53,8	38,705036	0	38,7
57-06-010	53,3	0	53,3	38,345324	0	38,3
57-06-020	53,3	0,9	54,2	38,992806	0	39
57-06-030	53,3	1,6	54,9	39,496403	0	39,5
57-06-040	53,3	2,3	55,6	40	0	40
57-06-050	53,3	3	56,3	40,503597	0	40,5
57-06-060	53,3	3,7	57	41,007194	0	41
57-06-070	53,3	4,4	57,7	41,510791	0	41,5
57-06-080	53,3	5,1	58,4	42,014388	0	42
57-06-090	53,3	5,8	59,1	42,517986	0	42,5
57-06-100	53,3	6,5	59,8	43,021583	0	43
56-01-010	23,3	0	23,3	16,76259	0	16,8

56-01-020	23,3	0,9	24,2	17,410072	0	17,4
56-01-030	23,3	1,6	24,9	17,913669	0	17,9
56-01-040	23,3	2,3	25,6	18,417266	0	18,4
56-01-050	23,3	3	26,3	18,920863	0	18,9
56-01-060	23,3	3,7	27	19,42446	0	19,4
56-01-070	23,3	4,4	27,7	19,928058	0	19,9
56-01-080	23,3	5,1	28,4	20,431655	0	20,4
56-01-090	23,3	5,8	29,1	20,935252	0	20,9
56-01-100	23,3	6,5	29,8	21,438849	0	21,4
56-02-010	27,8	0	27,8	20	0	20
56-02-020	27,8	0,9	28,7	20,647482	0	20,6
56-02-030	27,8	1,6	29,4	21,151079	0	21,2
56-02-040	27,8	2,3	30,1	21,654676	0	21,7
56-02-050	27,8	3	30,8	22,158273	0	22,2
56-02-060	27,8	3,7	31,5	22,661871	0	22,7
56-02-070	27,8	4,4	32,2	23,165468	0	23,2
56-02-080	27,8	5,1	32,9	23,669065	0	23,7
56-02-090	27,8	5,8	33,6	24,172662	0	24,2
56-02-100	27,8	6,5	34,3	24,676259	0	24,7
56-03-010	33,8	0	33,8	24,316547	0	24,3
56-03-020	33,8	0,9	34,7	24,964029	0	25
56-03-030	33,8	1,6	35,4	25,467626	0	25,5
56-03-040	33,8	2,3	36,1	25,971223	0	26
56-03-050	33,8	3	36,8	26,47482	0	26,5
56-03-060	33,8	3,7	37,5	26,978417	0	27
56-03-070	33,8	4,4	38,2	27,482014	0	27,5
56-03-080	33,8	5,1	38,9	27,985612	0	28
56-03-090	33,8	5,8	39,6	28,489209	0	28,5
56-03-100	33,8	6,5	40,3	28,992806	0	29
56-04-010	40,5	0	40,5	29,136691	0	29,1
56-04-020	40,5	0,9	41,4	29,784173	0	29,8
56-04-030	40,5	1,6	42,1	30,28777	0	30,3
56-04-040	40,5	2,3	42,8	30,791367	0	30,8
56-04-050	40,5	3	43,5	31,294964	0	31,3
56-04-060	40,5	3,7	44,2	31,798561	0	31,8
56-04-070	40,5	4,4	44,9	32,302158	0	32,3
56-04-080	40,5	5,1	45,6	32,805755	0	32,8
56-04-090	40,5	5,8	46,3	33,309353	0	33,3
56-04-100	40,5	6,5	47	33,81295	0	33,8
56-05-010	47,3	0	47,3	34,028777	0	34
56-05-020	47,3	0,9	48,2	34,676259	0	34,7
56-05-030	47,3	1,6	48,9	35,179856	0	35,2
56-05-040	47,3	2,3	49,6	35,683453	0	35,7
56-05-050	47,3	3	50,3	36,18705	0	36,2
56-05-060	47,3	3,7	51	36,690647	0	36,7
56-05-070	47,3	4,4	51,7	37,194245	0	37,2
56-05-080	47,3	5,1	52,4	37,697842	0	37,7
56-05-090	47,3	5,8	53,1	38,201439	0	38,2
56-05-100	47,3	6,5	53,8	38,705036	0	38,7
56-06-010	53,3		53,3	38,345324	0	38,3

56-06-020	53,3	0,9	54,2	38,992806	0	39
56-06-030	53,3	1,6	54,9	39,496403	0	39,5
56-06-040	53,3	2,3	55,6	40	0	40
56-06-050	53,3	3	56,3	40,503597	0	40,5
56-06-060	53,3	3,7	57	41,007194	0	41
56-06-070	53,3	4,4	57,7	41,510791	0	41,5
56-06-080	53,3	5,1	58,4	42,014388	0	42
56-06-090	53,3	5,8	59,1	42,517986	0	42,5
56-06-100	53,3	6,5	59,8	43,021583	0	43
55-01-010	30	0	30	21,582734	10	31,6
55-01-020	30	0,9	30,9	22,230216	10	32,2
55-01-030	30	1,6	31,6	22,733813	10	32,7
55-01-040	30	2,3	32,3	23,23741	10	33,2
55-01-050	30	3	33	23,741007	10	33,7
55-01-060	30	3,7	33,7	24,244604	10	34,2
55-01-070	30	4,4	34,4	24,748201	10	34,7
55-01-080	30	5,1	35,1	25,251799	10	35,3
55-01-090	30	5,8	35,8	25,755396	10	35,8
55-01-100	30	6,5	36,5	26,258993	10	36,3
55-02-010	35,3	0	35,3	25,395683	10	35,4
55-02-020	35,3	0,9	36,2	26,043165	10	36
55-02-030	35,3	1,6	36,9	26,546763	10	36,5
55-02-040	35,3	2,3	37,6	27,05036	10	37,1
55-02-050	35,3	3	38,3	27,553957	10	37,6
55-02-060	35,3	3,7	39	28,057554	10	38,1
55-02-070	35,3	4,4	39,7	28,561151	10	38,6
55-02-080	35,3	5,1	40,4	29,064748	10	39,1
55-02-090	35,3	5,8	41,1	29,568345	10	39,6
55-02-100	35,3	6,5	41,8	30,071942	10	40,1
55-03-010	40,5	0	40,5	29,136691	10	39,1
55-03-020	40,5	0,9	41,4	29,784173	10	39,8
55-03-030	40,5	1,6	42,1	30,28777	10	40,3
55-03-040	40,5	2,3	42,8	30,791367	10	40,8
55-03-050	40,5	3	43,5	31,294964	10	41,3
55-03-060	40,5	3,7	44,2	31,798561	10	41,8
55-03-070	40,5	4,4	44,9	32,302158	10	42,3
55-03-080	40,5	5,1	45,6	32,805755	10	42,8
55-03-090	40,5	5,8	46,3	33,309353	10	43,3
55-03-100	40,5	6,5	47	33,81295	10	43,8
55-04-010	46,5	0	46,5	33,453237	10	43,5
55-04-020	46,5	0,9	47,4	34,100719	10	44,1
55-04-030	46,5	1,6	48,1	34,604317	10	44,6
55-04-040	46,5	2,3	48,8	35,107914	10	45,1
55-04-050	46,5	3	49,5	35,611511	10	45,6
55-04-060	46,5	3,7	50,2	36,115108	10	46,1
55-04-070	46,5	4,4	50,9	36,618705	10	46,6
55-04-080	46,5	5,1	51,6	37,122302	10	47,1
55-04-090	46,5	5,8	52,3	37,625899	10	47,6
55-04-100	46,5	6,5	53	38,129496	10	48,1
55-05-010	52,5	0	52,5	37,769784	10	47,8

55-05-020	52,5	0,9	53,4	38,417266	10	48,4
55-05-030	52,5	1,6	54,1	38,920863	10	48,9
55-05-040	52,5	2,3	54,8	39,42446	10	49,4
55-05-050	52,5	3	55,5	39,928058	10	49,9
55-05-060	52,5	3,7	56,2	40,431655	10	50,4
55-05-070	52,5	4,4	56,9	40,935252	10	50,9
55-05-080	52,5	5,1	57,6	41,438849	10	51,4
55-05-090	52,5	5,8	58,3	41,942446	10	51,9
55-05-100	52,5	6,5	59	42,446043	10	52,4
55-06-010	58,5	0	58,5	42,086331	10	52,1
55-06-020	58,5	0,9	59,4	42,733813	10	52,7
55-06-030	58,5	1,6	60,1	43,23741	10	53,2
55-06-040	58,5	2,3	60,8	43,741007	10	53,7
55-06-050	58,5	3	61,5	44,244604	10	54,2
55-06-060	58,5	3,7	62,2	44,748201	10	54,7
55-06-070	58,5	4,4	62,9	45,251799	10	55,3
55-06-080	58,5	5,1	63,6	45,755396	10	55,8
55-06-090	58,5	5,8	64,3	46,258993	10	56,3
55-06-100	58,5	6,5	65	46,76259	10	56,8
54-01-010	30	0	30	21,582734	10	31,6
54-01-020	30	0,9	30,9	22,230216	10	32,2
54-01-030	30	1,6	31,6	22,733813	10	32,7
54-01-040	30	2,3	32,3	23,23741	10	33,2
54-01-050	30	3	33	23,741007	10	33,7
54-01-060	30	3,7	33,7	24,244604	10	34,2
54-01-070	30	4,4	34,4	24,748201	10	34,7
54-01-080	30	5,1	35,1	25,251799	10	35,3
54-01-090	30	5,8	35,8	25,755396	10	35,8
54-01-100	30	6,5	36,5	26,258993	10	36,3
54-02-010	35,3	0	35,3	25,395683	10	35,4
54-02-020	35,3	0,9	36,2	26,043165	10	36
54-02-030	35,3	1,6	36,9	26,546763	10	36,5
54-02-040	35,3	2,3	37,6	27,05036	10	37,1
54-02-050	35,3	3	38,3	27,553957	10	37,6
54-02-060	35,3	3,7	39	28,057554	10	38,1
54-02-070	35,3	4,4	39,7	28,561151	10	38,6
54-02-080	35,3	5,1	40,4	29,064748	10	39,1
54-02-090	35,3	5,8	41,1	29,568345	10	39,6
54-02-100	35,3	6,5	41,8	30,071942	10	40,1
54-03-010	40,5	0	40,5	29,136691	10	39,1
54-03-020	40,5	0,9	41,4	29,784173	10	39,8
54-03-030	40,5	1,6	42,1	30,28777	10	40,3
54-03-040	40,5	2,3	42,8	30,791367	10	40,8
54-03-050	40,5	3	43,5	31,294964	10	41,3
54-03-060	40,5	3,7	44,2	31,798561	10	41,8
54-03-070	40,5	4,4	44,9	32,302158	10	42,3
54-03-080	40,5	5,1	45,6	32,805755	10	42,8
54-03-090	40,5	5,8	46,3	33,309353	10	43,3
54-03-100	40,5	6,5	47	33,81295	10	43,8
54-04-010	46,5	0	46,5	33,453237	10	43,5

54-04-020	46,5	0,9	47,4	34,100719	10	44,1
54-04-030	46,5	1,6	48,1	34,604317	10	44,6
54-04-040	46,5	2,3	48,8	35,107914	10	45,1
54-04-050	46,5	3	49,5	35,611511	10	45,6
54-04-060	46,5	3,7	50,2	36,115108	10	46,1
54-04-070	46,5	4,4	50,9	36,618705	10	46,6
54-04-080	46,5	5,1	51,6	37,122302	10	47,1
54-04-090	46,5	5,8	52,3	37,625899	10	47,6
54-04-100	46,5	6,5	53	38,129496	10	48,1
54-05-010	52,5	0	52,5	37,769784	10	47,8
54-05-020	52,5	0,9	53,4	38,417266	10	48,4
54-05-030	52,5	1,6	54,1	38,920863	10	48,9
54-05-040	52,5	2,3	54,8	39,42446	10	49,4
54-05-050	52,5	3	55,5	39,928058	10	49,9
54-05-060	52,5	3,7	56,2	40,431655	10	50,4
54-05-070	52,5	4,4	56,9	40,935252	10	50,9
54-05-080	52,5	5,1	57,6	41,438849	10	51,4
54-05-090	52,5	5,8	58,3	41,942446	10	51,9
54-05-100	52,5	6,5	59	42,446043	10	52,4
54-06-010	58,5	0	58,5	42,086331	10	52,1
54-06-020	58,5	0,9	59,4	42,733813	10	52,7
54-06-030	58,5	1,6	60,1	43,23741	10	53,2
54-06-040	58,5	2,3	60,8	43,741007	10	53,7
54-06-050	58,5	3	61,5	44,244604	10	54,2
54-06-060	58,5	3,7	62,2	44,748201	10	54,7
54-06-070	58,5	4,4	62,9	45,251799	10	55,3
53-01-010	35,3	0	35,3	25,395683	13	38,4
53-01-020	35,3	0,9	36,2	26,043165	13	39
53-01-030	35,3	1,6	36,9	26,546763	13	39,5
53-01-040	35,3	2,3	37,6	27,05036	13	40,1
53-01-050	35,3	3	38,3	27,553957	13	40,6
53-01-060	35,3	3,7	39	28,057554	13	41,1
53-01-070	35,3	4,4	39,7	28,561151	13	41,6
53-01-080	35,3	5,1	40,4	29,064748	13	42,1
53-01-090	35,3	5,8	41,1	29,568345	13	42,6
53-01-100	35,3	6,5	41,8	30,071942	13	43,1
53-02-010	40,5	0	40,5	29,136691	13	42,1
53-02-020	40,5	0,9	41,4	29,784173	13	42,8
53-02-030	40,5	1,6	42,1	30,28777	13	43,3
53-02-040	40,5	2,3	42,8	30,791367	13	43,8
53-02-050	40,5	3	43,5	31,294964	13	44,3
53-02-060	40,5	3,7	44,2	31,798561	13	44,8
53-02-070	40,5	4,4	44,9	32,302158	13	45,3
53-02-080	40,5	5,1	45,6	32,805755	13	45,8
53-02-090	40,5	5,8	46,3	33,309353	13	46,3
53-02-100	40,5	6,5	47	33,81295	13	46,8
53-03-010	46,5	0	46,5	33,453237	13	46,5
53-03-020	46,5	0,9	47,4	34,100719	13	47,1
53-03-030	46,5	1,6	48,1	34,604317	13	47,6
53-03-040	46,5	2,3	48,8	35,107914	13	48,1

53-03-050	46,5	3	49,5	35,611511	13	48,6
53-03-060	46,5	3,7	50,2	36,115108	13	49,1
53-03-070	46,5	4,4	50,9	36,618705	13	49,6
53-03-080	46,5	5,1	51,6	37,122302	13	50,1
53-03-090	46,5	5,8	52,3	37,625899	13	50,6
53-03-100	46,5	6,5	53	38,129496	13	51,1
53-04-010	51,8	0	51,8	37,266187	13	50,3
53-04-020	51,8	0,9	52,7	37,913669	13	50,9
53-04-030	51,8	1,6	53,4	38,417266	13	51,4
53-04-040	51,8	2,3	54,1	38,920863	13	51,9
53-04-050	51,8	3	54,8	39,42446	13	52,4
53-04-060	51,8	3,7	55,5	39,928058	13	52,9
53-04-070	51,8	4,4	56,2	40,431655	13	53,4
53-04-080	51,8	5,1	56,9	40,935252	13	53,9
53-04-090	51,8	5,8	57,6	41,438849	13	54,4
53-04-100	51,8	6,5	58,3	41,942446	13	54,9
53-05-010	57,8	0	57,8	41,582734	13	54,6
53-05-020	57,8	0,9	58,7	42,230216	13	55,2
53-05-030	57,8	1,6	59,4	42,733813	13	55,7
53-05-040	57,8	2,3	60,1	43,23741	13	56,2
53-05-050	57,8	3	60,8	43,741007	13	56,7
53-05-060	57,8	3,7	61,5	44,244604	13	57,2
53-05-070	57,8	4,4	62,2	44,748201	13	57,7
53-05-080	57,8	5,1	62,9	45,251799	13	58,3
53-05-090	57,8	5,8	63,6	45,755396	13	58,8
53-05-100	57,8	6,5	64,3	46,258993	13	59,3
53-06-010	63,8	0	63,8	45,899281	13	58,9
53-06-020	63,8	0,9	64,7	46,546763	13	59,5
53-06-030	63,8	1,6	65,4	47,05036	13	60,1
53-06-040	63,8	2,3	66,1	47,553957	13	60,6
53-06-050	63,8	3	66,8	48,057554	13	61,1
53-06-060	63,8	3,7	67,5	48,561151	13	61,6
53-06-070	63,8	4,4	68,2	49,064748	13	62,1
52-01-010	35,3	0	35,3	25,395683	13	38,4
52-01-020	35,3	0,9	36,2	26,043165	13	39
52-01-030	35,3	1,6	36,9	26,546763	13	39,5
52-01-040	35,3	2,3	37,6	27,05036	13	40,1
52-01-050	35,3	3	38,3	27,553957	13	40,6
52-01-060	35,3	3,7	39	28,057554	13	41,1
52-01-070	35,3	4,4	39,7	28,561151	13	41,6
52-01-080	35,3	5,1	40,4	29,064748	13	42,1
52-01-090	35,3	5,8	41,1	29,568345	13	42,6
52-01-100	35,3	6,5	41,8	30,071942	13	43,1
52-02-010	40,5	0	40,5	29,136691	13	42,1
52-02-020	40,5	0,9	41,4	29,784173	13	42,8
52-02-030	40,5	1,6	42,1	30,28777	13	43,3
52-02-040	40,5	2,3	42,8	30,791367	13	43,8
52-02-050	40,5	3	43,5	31,294964	13	44,3
52-02-060	40,5	3,7	44,2	31,798561	13	44,8
52-02-070	40,5	4,4	44,9	32,302158	13	45,3

52-02-080	40,5	5,1	45,6	32,805755	13	45,8
52-02-090	40,5	5,8	46,3	33,309353	13	46,3
52-02-100	40,5	6,5	47	33,81295	13	46,8
52-03-010	46,5	0	46,5	33,453237	13	46,5
52-03-020	46,5	0,9	47,4	34,100719	13	47,1
52-03-030	46,5	1,6	48,1	34,604317	13	47,6
52-03-040	46,5	2,3	48,8	35,107914	13	48,1
52-03-050	46,5	3	49,5	35,611511	13	48,6
52-03-060	46,5	3,7	50,2	36,115108	13	49,1
52-03-070	46,5	4,4	50,9	36,618705	13	49,6
52-03-080	46,5	5,1	51,6	37,122302	13	50,1
52-03-090	46,5	5,8	52,3	37,625899	13	50,6
52-03-100	46,5	6,5	53	38,129496	13	51,1
52-04-010	51,8	0	51,8	37,266187	13	50,3
52-04-020	51,8	0,9	52,7	37,913669	13	50,9
52-04-030	51,8	1,6	53,4	38,417266	13	51,4
52-04-040	51,8	2,3	54,1	38,920863	13	51,9
52-04-050	51,8	3	54,8	39,42446	13	52,4
52-04-060	51,8	3,7	55,5	39,928058	13	52,9
52-04-070	51,8	4,4	56,2	40,431655	13	53,4
52-04-080	51,8	5,1	56,9	40,935252	13	53,9
52-04-090	51,8	5,8	57,6	41,438849	13	54,4
52-04-100	51,8	6,5	58,3	41,942446	13	54,9
52-05-010	57,8	0	57,8	41,582734	13	54,6
52-05-020	57,8	0,9	58,7	42,230216	13	55,2
52-05-030	57,8	1,6	59,4	42,733813	13	55,7
52-05-040	57,8	2,3	60,1	43,23741	13	56,2
52-05-050	57,8	3	60,8	43,741007	13	56,7
52-05-060	57,8	3,7	61,5	44,244604	13	57,2
52-05-070	57,8	4,4	62,2	44,748201	13	57,7
52-05-080	57,8	5,1	62,9	45,251799	13	58,3
52-05-090	57,8	5,8	63,6	45,755396	13	58,8
52-05-100	57,8	6,5	64,3	46,258993	13	59,3
52-06-010	63,8	0	63,8	45,899281	13	58,9
52-06-020	63,8	0,9	64,7	46,546763	13	59,5
52-06-030	63,8	1,6	65,4	47,05036	13	60,1
52-06-040	63,8	2,3	66,1	47,553957	13	60,6
52-06-050	63,8	3	66,8	48,057554	13	61,1
52-06-060	63,8	3,7	67,5	48,561151	13	61,6
52-06-070	63,8	4,4	68,2	49,064748	13	62,1
52-06-080	63,8	5,1	68,9	49,568345	13	62,6
52-06-090	63,8	5,8	69,6	50,071942	13	63,1
52-06-100	63,8	6,5	70,3	50,57554	13	63,6
51-01-010	41,3	0	41,3	29,71223	16	45,7
51-01-020	41,3	0,9	42,2	30,359712	16	46,4
51-01-030	41,3	1,6	42,9	30,863309	16	46,9
51-01-040	41,3	2,3	43,6	31,366906	16	47,4
51-01-050	41,3	3	44,3	31,870504	16	47,9
51-01-060	41,3	3,7	45	32,374101	16	48,4
51-01-070	41,3	4,4	45,7	32,877698	16	48,9

51-01-080	41,3	5,1	46,4	33,381295	16	49,4
51-01-090	41,3	5,8	47,1	33,884892	16	49,9
51-01-100	41,3	6,5	47,8	34,388489	16	50,4
51-02-010	46,5	0	46,5	33,453237	16	49,5
51-02-020	46,5	0,9	47,4	34,100719	16	50,1
51-02-030	46,5	1,6	48,1	34,604317	16	50,6
51-02-040	46,5	2,3	48,8	35,107914	16	51,1
51-02-050	46,5	3	49,5	35,611511	16	51,6
51-02-060	46,5	3,7	50,2	36,115108	16	52,1
51-02-070	46,5	4,4	50,9	36,618705	16	52,6
51-02-080	46,5	5,1	51,6	37,122302	16	53,1
51-02-090	46,5	5,8	52,3	37,625899	16	53,6
51-02-100	46,5	6,5	53	38,129496	16	54,1
51-03-010	51,8	0	51,8	37,266187	16	53,3
51-03-020	51,8	0,9	52,7	37,913669	16	53,9
51-03-030	51,8	1,6	53,4	38,417266	16	54,4
51-03-040	51,8	2,3	54,1	38,920863	16	54,9
51-03-050	51,8	3	54,8	39,42446	16	55,4
51-03-060	51,8	3,7	55,5	39,928058	16	55,9
51-03-070	51,8	4,4	56,2	40,431655	16	56,4
51-03-080	51,8	5,1	56,9	40,935252	16	56,9
51-03-090	51,8	5,8	57,6	41,438849	16	57,4
51-03-100	51,8	6,5	58,3	41,942446	16	57,9
51-04-010	57,8	0	57,8	41,582734	16	57,6
51-04-020	57,8	0,9	58,7	42,230216	16	58,2
51-04-030	57,8	1,6	59,4	42,733813	16	58,7
51-04-040	57,8	2,3	60,1	43,23741	16	59,2
51-04-050	57,8	3	60,8	43,741007	16	59,7
51-04-060	57,8	3,7	61,5	44,244604	16	60,2
51-04-070	57,8	4,4	62,2	44,748201	16	60,7
51-04-080	57,8	5,1	62,9	45,251799	16	61,3
51-04-090	57,8	5,8	63,6	45,755396	16	61,8
51-04-100	57,8	6,5	64,3	46,258993	16	62,3
51-05-010	63,8	0	63,8	45,899281	16	61,9
51-05-020	63,8	0,9	64,7	46,546763	16	62,5
51-05-030	63,8	1,6	65,4	47,05036	16	63,1
51-05-040	63,8	2,3	66,1	47,553957	16	63,6
51-05-050	63,8	3	66,8	48,057554	16	64,1
51-05-060	63,8	3,7	67,5	48,561151	16	64,6
51-05-070	63,8	4,4	68,2	49,064748	16	65,1
51-05-080	63,8	5,1	68,9	49,568345	16	65,6
51-05-090	63,8	5,8	69,6	50,071942	16	66,1
51-05-100	63,8	6,5	70,3	50,57554	16	66,6
51-06-010	69,8	0	69,8	50,215827	16	66,2
51-06-020	69,8	0,9	70,7	50,863309	16	66,9
51-06-030	69,8	1,6	71,4	51,366906	16	67,4
51-06-040	69,8	2,3	72,1	51,870504	16	67,9
51-06-050	69,8	3	72,8	52,374101	16	68,4
51-06-060	69,8	3,7	73,5	52,877698	16	68,9
51-06-070	69,8	4,4	74,2	53,381295	16	69,4

51-06-080	69,8	5,1	74,9	53,884892	16	69,9
51-06-090	69,8	5,8	75,6	54,388489	16	70,4
51-06-100	69,8	6,5	76,3	54,892086	16	70,9
50-01-010	41,3	0	41,3	29,71223	16	45,7
50-01-020	41,3	0,9	42,2	30,359712	16	46,4
50-01-030	41,3	1,6	42,9	30,863309	16	46,9
50-01-040	41,3	2,3	43,6	31,366906	16	47,4
50-01-050	41,3	3	44,3	31,870504	16	47,9
50-01-060	41,3	3,7	45	32,374101	16	48,4
50-01-070	41,3	4,4	45,7	32,877698	16	48,9
50-01-080	41,3	5,1	46,4	33,381295	16	49,4
50-01-090	41,3	5,8	47,1	33,884892	16	49,9
50-01-100	41,3	6,5	47,8	34,388489	16	50,4
50-02-010	46,5	0	46,5	33,453237	16	49,5
50-02-020	46,5	0,9	47,4	34,100719	16	50,1
51-04-030	46,5	1,6	48,1	34,604317	16	50,6
50-02-040	46,5	2,3	48,8	35,107914	16	51,1
50-02-050	46,5	3	49,5	35,611511	16	51,6
50-02-060	46,5	3,7	50,2	36,115108	16	52,1
50-02-070	46,5	4,4	50,9	36,618705	16	52,6
50-02-080	46,5	5,1	51,6	37,122302	16	53,1
50-02-090	46,5	5,8	52,3	37,625899	16	53,6
50-02-100	46,5	6,5	53	38,129496	16	54,1
50-03-010	51,8	0	51,8	37,266187	16	53,3
50-03-020	51,8	0,9	52,7	37,913669	16	53,9
50-03-030	51,8	1,6	53,4	38,417266	16	54,4
50-03-040	51,8	2,3	54,1	38,920863	16	54,9
50-03-050	51,8	3	54,8	39,42446	16	55,4
50-03-060	51,8	3,7	55,5	39,928058	16	55,9
50-03-070	51,8	4,4	56,2	40,431655	16	56,4
50-03-080	51,8	5,1	56,9	40,935252	16	56,9
50-03-090	51,8	5,8	57,6	41,438849	16	57,4
50-03-100	51,8	6,5	58,3	41,942446	16	57,9
50-04-010	57,8	0	57,8	41,582734	16	57,6
50-04-020	57,8	0,9	58,7	42,230216	16	58,2
50-04-030	57,8	1,6	59,4	42,733813	16	58,7
50-04-040	57,8	2,3	60,1	43,23741	16	59,2
50-04-050	57,8	3	60,8	43,741007	16	59,7
50-04-060	57,8	3,7	61,5	44,244604	16	60,2
50-04-070	57,8	4,4	62,2	44,748201	16	60,7
50-04-080	57,8	5,1	62,9	45,251799	16	61,3
50-04-090	57,8	5,8	63,6	45,755396	16	61,8
50-04-100	57,8	6,5	64,3	46,258993	16	62,3
50-05-010	63,8	0	63,8	45,899281	16	61,9
50-05-020	63,8	0,9	64,7	46,546763	16	62,5
50-05-030	63,8	1,6	65,4	47,05036	16	63,1
50-05-040	63,8	2,3	66,1	47,553957	16	63,6
50-05-050	63,8	3	66,8	48,057554	16	64,1
50-05-060	63,8	3,7	67,5	48,561151	16	64,6
50-05-070	63,8	4,4	68,2	49,064748	16	65,1

50-05-080	63,8	5,1	68,9	49,568345	16	65,6
50-05-090	63,8	5,8	69,6	50,071942	16	66,1
50-05-100	63,8	6,5	70,3	50,57554	16	66,6
50-06-010	69,8	0	69,8	50,215827	16	66,2
50-06-020	69,8	0,9	70,7	50,863309	16	66,9
50-06-030	69,8	1,6	71,4	51,366906	16	67,4
50-06-040	69,8	2,3	72,1	51,870504	16	67,9
50-06-050	69,8	3	72,8	52,374101	16	68,4
50-06-060	69,8	3,7	73,5	52,877698	16	68,9
50-06-070	69,8	4,4	74,2	53,381295	16	69,4
50-06-080	69,8	5,1	74,9	53,884892	16	69,9
50-06-090	69,8	5,8	75,6	54,388489	16	70,4
50-06-100	69,8	6,5	76,3	54,892086	16	70,9
49-01-010	47,3	0	47,3	34,028777	19	53
49-01-020	47,3	0,9	48,2	34,676259	19	53,7
49-01-030	47,3	1,6	48,9	35,179856	19	54,2
49-01-040	47,3	2,3	49,6	35,683453	19	54,7
49-01-050	47,3	3	50,3	36,18705	19	55,2
49-01-060	47,3	3,7	51	36,690647	19	55,7
49-01-070	47,3	4,4	51,7	37,194245	19	56,2
49-01-080	47,3	5,1	52,4	37,697842	19	56,7
49-01-090	47,3	5,8	53,1	38,201439	19	57,2
49-01-100	47,3	6,5	53,8	38,705036	19	57,7
49-02-010	52,5	0	52,5	37,769784	19	56,8
49-02-020	52,5	0,9	53,4	38,417266	19	57,4
49-02-030	52,5	1,6	54,1	38,920863	19	57,9
49-02-040	52,5	2,3	54,8	39,42446	19	58,4
49-02-050	52,5	3	55,5	39,928058	19	58,9
49-02-060	52,5	3,7	56,2	40,431655	19	59,4
49-02-070	52,5	4,4	56,9	40,935252	19	59,9
49-02-080	52,5	5,1	57,6	41,438849	19	60,4
49-02-090	52,5	5,8	58,3	41,942446	19	60,9
49-02-100	52,5	6,5	59	42,446043	19	61,4
49-03-010	57	0	57	41,007194	19	60
49-03-020	57	0,9	57,9	41,654676	19	60,7
49-03-030	57	1,6	58,6	42,158273	19	61,2
49-03-040	57	2,3	59,3	42,661871	19	61,7
49-03-050	57	3	60	43,165468	19	62,2
49-03-060	57	3,7	60,7	43,669065	19	62,7
49-03-070	57	4,4	61,4	44,172662	19	63,2
49-03-080	57	5,1	62,1	44,676259	19	63,7
49-03-090	57	5,8	62,8	45,179856	19	64,2
49-03-100	57	6,5	63,5	45,683453	19	64,7
49-04-010	63	0	63	45,323741	19	64,3
49-04-020	63	0,9	63,9	45,971223	19	65
49-04-030	63	1,6	64,6	46,47482	19	65,5
49-04-040	63	2,3	65,3	46,978417	19	66
49-04-050	63	3	66	47,482014	19	66,5
49-04-060	63	3,7	66,7	47,985612	19	67
49-04-070	63	4,4	67,4	48,489209	19	67,5

49-04-080	63	5,1	68,1	48,992806	19	68
49-04-090	63	5,8	68,8	49,496403	19	68,5
49-04-100	63	6,5	69,5	50	19	69
49-05-010	69,8	0	69,8	50,215827	19	69,2
49-05-020	69,8	0,9	70,7	50,863309	19	69,9
49-05-030	69,8	1,6	71,4	51,366906	19	70,4
49-05-040	69,8	2,3	72,1	51,870504	19	70,9
49-05-050	69,8	3	72,8	52,374101	19	71,4
49-05-060	69,8	3,7	73,5	52,877698	19	71,9
49-05-070	69,8	4,4	74,2	53,381295	19	72,4
49-05-080	69,8	5,1	74,9	53,884892	19	72,9
49-05-090	69,8	5,8	75,6	54,388489	19	73,4
49-05-100	69,8	6,5	76,3	54,892086	19	73,9
49-06-010	75,8	0	75,8	54,532374	19	73,5
49-06-020	75,8	0,9	76,7	55,179856	19	74,2
49-06-030	75,8	1,6	77,4	55,683453	19	74,7
49-06-040	75,8	2,3	78,1	56,18705	19	75,2
49-06-050	75,8	3	78,8	56,690647	19	75,7
49-06-060	75,8	3,7	79,5	57,194245	19	76,2
49-06-070	75,8	4,4	80,2	57,697842	19	76,7
49-06-080	75,8	5,1	80,9	58,201439	19	77,2
49-06-090	75,8	5,8	81,6	58,705036	19	77,7
49-06-100	75,8	6,5	82,3	59,208633	19	78,2
48-01-010	47,3	0	47,3	34,028777	19	53
48-01-020	47,3	0,9	48,2	34,676259	19	53,7
48-01-030	47,3	1,6	48,9	35,179856	19	54,2
48-01-040	47,3	2,3	49,6	35,683453	19	54,7
48-01-050	47,3	3	50,3	36,18705	19	55,2
48-01-060	47,3	3,7	51	36,690647	19	55,7
48-01-070	47,3	4,4	51,7	37,194245	19	56,2
48-01-080	47,3	5,1	52,4	37,697842	19	56,7
48-01-090	47,3	5,8	53,1	38,201439	19	57,2
48-01-100	47,3	6,5	53,8	38,705036	19	57,7
48-02-010	52,5	0	52,5	37,769784	19	56,8
48-02-020	52,5	0,9	53,4	38,417266	19	57,4
48-02-030	52,5	1,6	54,1	38,920863	19	57,9
48-02-040	52,5	2,3	54,8	39,42446	19	58,4
48-02-050	52,5	3	55,5	39,928058	19	58,9
48-02-060	52,5	3,7	56,2	40,431655	19	59,4
48-02-070	52,5	4,4	56,9	40,935252	19	59,9
48-02-080	52,5	5,1	57,6	41,438849	19	60,4
48-02-090	52,5	5,8	58,3	41,942446	19	60,9
48-02-100	52,5	6,5	59	42,446043	19	61,4
48-03-010	57	0	57	41,007194	19	60
48-03-020	57	0,9	57,9	41,654676	19	60,7
48-03-030	57	1,6	58,6	42,158273	19	61,2
48-03-040	57	2,3	59,3	42,661871	19	61,7
48-03-050	57	3	60	43,165468	19	62,2
48-03-060	57	3,7	60,7	43,669065	19	62,7
48-03-070	57	4,4	61,4	44,172662	19	63,2

48-03-080	57	5,1	62,1	44,676259	19	63,7
48-03-090	57	5,8	62,8	45,179856	19	64,2
48-03-100	57	6,5	63,5	45,683453	19	64,7
48-04-010	63	0	63	45,323741	19	64,3
48-04-020	63	0,9	63,9	45,971223	19	65
48-04-030	63	1,6	64,6	46,47482	19	65,5
48-04-040	63	2,3	65,3	46,978417	19	66
48-04-050	63	3	66	47,482014	19	66,5
48-04-060	63	3,7	66,7	47,985612	19	67
48-04-070	63	4,4	67,4	48,489209	19	67,5
48-04-080	63	5,1	68,1	48,992806	19	68
48-04-090	63	5,8	68,8	49,496403	19	68,5
48-04-100	63	6,5	69,5	50	19	69
48-05-010	69,8	0	69,8	50,215827	19	69,2
48-05-020	69,8	0,9	70,7	50,863309	19	69,9
48-05-030	69,8	1,6	71,4	51,366906	19	70,4
48-05-040	69,8	2,3	72,1	51,870504	19	70,9
48-05-050	69,8	3	72,8	52,374101	19	71,4
48-05-060	69,8	3,7	73,5	52,877698	19	71,9
48-05-070	69,8	4,4	74,2	53,381295	19	72,4
48-05-080	69,8	5,1	74,9	53,884892	19	72,9
48-05-090	69,8	5,8	75,6	54,388489	19	73,4
48-05-100	69,8	6,5	76,3	54,892086	19	73,9
48-06-010	75,8	0	75,8	54,532374	19	73,5
48-06-020	75,8	0,9	76,7	55,179856	19	74,2
48-06-030	75,8	1,6	77,4	55,683453	19	74,7
48-06-040	75,8	2,3	78,1	56,18705	19	75,2
48-06-050	75,8	3	78,8	56,690647	19	75,7
48-06-060	75,8	3,7	79,5	57,194245	19	76,2
48-06-070	75,8	4,4	80,2	57,697842	19	76,7
48-06-080	75,8	5,1	80,9	58,201439	19	77,2
48-06-090	75,8	5,8	81,6	58,705036	19	77,7
48-06-100	75,8	6,5	82,3	59,208633	19	78,2

Appendix 6

Three zones within the hot zon is shown in green color tones. White parties are placements outside the hot zone and yellow parties are the aisles

Placement: seconds from cutting area	Quantity
Below 20 sec	64
Below 25 sec	82
Below 30 sec	60
Total	206
Standard placement pieces	30 same as hot zone

48	**48-01-100:** 57.7	**48-02-100:** 61.4	**48-03-100:** 64.7	**48-04-100:** 69.0	**48-05-100:** 73.9	**48-06-100:** 78.2
	48-01-090: 57.2	**48-02-090:** 60.9	**48-03-090:** 64.2	**48-04-090:** 68.5	**48-05-090:** 73.4	**48-06-090:** 77.7
	48-01-080: 56.7	**48-02-080:** 60.4	**48-03-080:** 63.7	**48-04-080:** 68.0	**48-05-080:** 72.9	**48-06-080:** 77.2
	48-01-070: 56.2	**48-02-070:** 59.9	**48-03-070:** 63.2	**48-04-070:** 67.5	**48-05-070:** 72.4	**48-06-070:** 76.7
10+9	**48-01-060:** 55.7	**48-02-060:** 59.4	**48-03-060:** 62.7	**48-04-060:** 67.0	**48-05-060:** 71.9	**48-06-060:** 76.2
	48-01-050: 55.2	**48-02-050:** 58.9	**48-03-050:** 62.2	**48-04-050:** 66.5	**48-05-050:** 71.4	**48-06-050:** 75.7
	48-01-040: 54.7	**48-02-040:** 58.4	**48-03-040:** 61.7	**48-04-040:** 66.0	**48-05-040:** 70.9	**48-06-040:** 75.2
	48-01-030: 54.2	**48-02-030:** 57.9	**48-03-030:** 61.2	**48-04-030:** 65.5	**48-05-030:** 70.4	**48-06-030:** 74.7
	48-01-020: 53.7	**48-02-020:** 57.4	**48-03-020:** 60.7	**48-04-020:** 65.0	**48-05-020:** 69.9	**48-06-020:** 74.2
	48-01-010: 53.0	**48-02-010:** 56.8	**48-03-010:** 60.0	**48-04-010:** 64.3	**48-05-010:** 69.2	**48-06-010:** 73.5
alley						
49	**49-01-100:** 57.7	**49-02-100:** 61.4	**49-03-100:** 64.7	**49-04-100: 69.0**	**49-05-100:** 73.9	**49-06-100:** 78.2
	49-01-090: 57.2	**49-02-090:** 60.9	**49-03-090:** 64.2	**49-04-090:** 68.5	**49-05-090:** 73.4	**49-06-090:** 77.7
	49-01-080: 56.7	**49-02-080:** 60.4	**49-03-080:** 63.7	**49-04-080:** 68.0	**49-05-080:** 72.9	**49-06-080:** 77.2
	49-01-070: 56.2	**49-02-070:** 59.9	**49-03-070:** 63.2	**49-04-070:** 67.5	**49-05-070:** 72.4	**49-06-070:** 76.7
10+9	**49-01-060:** 55.7	**49-02-060:** 59.4	**49-03-060:** 62.7	**49-04-060:** 67.0	**49-05-060:** 71.9	**49-06-060:** 76.2
	49-01-050: 55.2	**49-02-050:** 58.9	**49-03-050:** 62.2	**49-04-050:** 66.5	**49-05-050:** 71.4	**49-06-050:** 75.7
	49-01-040: 54.7	**49-02-040:** 58.4	**49-03-040:** 61.7	**49-04-040:** 66.0	**49-05-040:** 70.9	**49-06-040:** 75.2
	49-01-030: 54.2	**49-02-030:** 57.9	**49-03-030:** 61.2	**49-04-030:** 65.5	**49-05-030:** 70.4	**49-06-030:** 74.7
	49-01-020: 53.7	**49-02-020:** 57.4	**49-03-020:** 60.7	**49-04-020:** 65.0	**49-05-020:** 69.9	**49-06-020:** 74.2
	49-01-010: 53.0	**49-02-010:** 56.8	**49-03-010:** 60.0	**49-04-010:** 64.3	**49-05-010:** 69.2	**49-06-010:** 73.5
50	**50-01-100:** 50.4	**50-02-100:** 54.1	**50-03-100:** 57.9	**50-04-100:** 62.3	**50-05-100:** 66.6	**50-06-100:** 70.9
	50-01-090: 49.9	**50-02-090:** 53.6	**50-03-090:** 57.4	**50-04-090:** 61.8	**50-05-090:** 66.1	**50-06-090:** 70.4
	50-01-080: 49.4	**50-02-080:** 53.1	**50-03-080:** 56.9	**50-04-080:** 61.3	**50-05-080:** 65.6	**50-06-080:** 69.9
	50-01-070: 48.9	**50-02-070:** 52.6	**50-03-070:** 56.4	**50-04-070:** 60.7	**50-05-070:** 65.1	**50-06-070:** 69.4
10+6	**50-01-060:** 48.4	**50-02-060:** 52.1	**50-03-060:** 55.9	**50-04-060:** 60.2	**50-05-060:** 64.6	**50-06-060:** 68.9
	50-01-050: 47.9	**50-02-050:** 51.6	**50-03-050:** 55.4	**50-04-050:** 59.7	**50-05-050:** 64.1	**50-06-050:** 68.4
	50-01-040: 47.4	**50-02-040:** 51.1	**50-03-040:** 54.9	**50-04-040:** 59.2	**50-05-040:** 63.6	**50-06-040:** 67.9
	50-01-030: 46.9	**50-02-030:** 50.6	**50-03-030:** 54.4	**50-04-030:** 58.7	**50-05-030:** 63.1	**50-06-030:** 67.4
	50-01-020: 46.4	**50-02-020:** 50.1	**50-03-020:** 53.9	**50-04-020:** 58.2	**50-05-020:** 62.5	**50-06-020:** 66.9
	50-01-010: 45.7	**50-02-010:** 49.5	**50-03-010:** 53.3	**50-04-010:** 57.6	**50-05-010:** 61.9	**50-06-010:** 66.2
51	**51-01-100:** 50.4	**51-02-100:** 54.1	**51-03-100:** 57.9	**51-04-100:** 62.3	**51-05-100:** 66.6	**51-06-100:** 70.9
	51-01-090: 49.9	**51-02-090:** 53.6	**51-03-090:** 57.4	**51-04-090:** 61.8	**51-05-090:** 66.1	**51-06-090:** 70.4
	51-01-080: 49.4	**51-02-080:** 53.1	**51-03-080:** 56.9	**51-04-080:** 61.3	**51-05-080:** 65.6	**51-06-080:** 69.9
	51-01-070: 48.9	**51-02-070:** 52.6	**51-03-070:** 56.4	**51-04-070:** 60.7	**51-05-070:** 65.1	**51-06-070:** 69.4
10+6	**51-01-060:** 48.4	**51-02-060:** 52.1	**51-03-060:** 55.9	**51-04-060:** 60.2	**51-05-060:** 64.6	**51-06-060:** 68.9

	51-01-051: 47.9	**51-02-051:** 51.6	**51-03-051:** 55.4	**51-04-051:** 59.7	**51-05-051:** 64.1	**51-06-050:** 68.4
	51-01-040: 47.4	**51-02-040:** 51.2	**51-03-040:** 54.9	**51-04-040:** 59.2	**51-05-040:** 63.6	**51-06-040:** 67.9
	51-01-030: 46.9	**51-02-030:** 50.6	**51-03-030:** 54.4	**51-04-030:** 58.7	**51-05-030:** 63.1	**51-06-030:** 67.4
	51-01-020: 46.4	**51-02-020:** 50.1	**51-03-020:** 53.9	**51-04-020:** 58.2	**51-05-020:** 62.5	**51-06-020:** 66.9
	51-01-010: 45.7	**51-02-010:** 49.5	**51-03-010:** 53.3	**51-04-010:** 57.6	**51-05-010:** 61.9	**51-06-010:** 66.2
52	**52-01-100:** 43.1	**52-02-100:** 46.8	**52-03-100:** 51.1	**52-04-100:** 54.9	**52-05-100:** 59.3	**52-06-100:** 63.6
	52-01-090: 42.6	**52-02-090:** 46.3	**52-03-090:** 50.6	**52-04-090:** 54.4	**52-05-090:** 58.8	**52-06-090:** 63.1
	52-01-080: 42.1	**52-02-080:** 45.8	**52-03-080:** 50.1	**52-04-080:** 53.9	**52-05-080:** 58.3	**52-06-080:** 62.6
	52-01-070: 41.6	**52-02-070:** 45.3	**52-03-070:** 49.6	**52-04-070:** 53.4	**52-05-070:** 57.7	**52-06-070:** 62.1
10+3	**52-01-060:** 41.1	**52-02-060:** 44.8	**52-03-060:** 49.1	**52-04-060:** 52.9	**52-05-060:** 57.2	**52-06-060:** 61.6
	52-01-050: 40.6	**52-02-050:** 44.3	**52-03-050:** 48.6	**52-04-050:** 52.4	**52-05-050:** 56.7	**52-06-050:** 61.1
	52-01-040: 40.1	**52-02-040:** 43.8	**52-03-040:** 48.1	**52-04-040:** 51.9	**52-05-040:** 56.2	**52-06-040:** 60.6
	52-01-030: 39.5	**52-02-030:** 43.3	**52-03-030:** 47.6	**52-04-030:** 51.4	**52-05-030:** 55.7	**52-06-030:** 60.1
	52-01-020: 39.0	**52-02-020:** 42.8	**52-03-020:** 47.1	**52-04-020:** 50.9	**52-05-020:** 55.2	**52-06-020:** 59.6
	52-01-010: 38.4	**52-02-010:** 42.1	**52-03-010:** 46.5	**52-04-010:** 50.3	**52-05-010:** 54.6	**52-06-010:** 59.1
53	**53-01-100:** 43.1	**53-02-100:** 46.8	**53-03-100:** 51.1	**53-04-100:** 54.9	**53-05-100:** 59.3	
	53-01-090: 42.6	**53-02-090:** 46.3	**53-03-090:** 50.6	**53-04-090:** 54.4	**53-05-090:** 58.8	
	53-01-080: 42.1	**53-02-080:** 45.8	**53-03-080:** 50.1	**53-04-080:** 53.9	**53-05-080:** 58.3	
	53-01-070: 41.6	**53-02-070:** 45.3	**53-03-070:** 49.6	**53-04-070:** 53.4	**53-05-070:** 47.7	**53-06-070:** 62.1
10+3	**53-01-060:** 41.1	**53-02-060:** 44.8	**53-03-060:** 49.1	**53-04-060:** 52.9	**53-05-060:** 57.2	**53-06-060:** 61.6
	53-01-050: 40.6	**53-02-050:** 44.3	**53-03-050:** 48.6	**53-04-050:** 52.4	**53-05-050:** 56.7	**53-06-050:** 61.1
	53-01-040: 40.1	**53-02-040:** 43.8	**53-03-040:** 48.1	**53-04-040:** 51.9	**53-05-040:** 56.2	**53-06-040:** 60.6
	53-01-030: 39.5	**53-02-030:** 43.3	**53-03-030:** 47.6	**53-04-030:** 51.4	**53-05-030:** 55.7	**53-06-030:** 60.1
	53-01-020: 39.0	**53-02-020:** 42.8	**53-03-020:** 47.1	**53-04-020:** 50.9	**53-05-020:** 55.2	**53-06-020:** 59.5
	53-01-010: 38.4	**53-02-010:** 42.1	**53-03-010:** 46.5	**53-04-010:** 50.4	**53-05-010:** 54.6	**53-06-010:** 54.9
54	**54-01-100:** 36.3	**54-02-100:** 40.1	**54-03-100:** 43.8	**54-04-100:** 48.1	**54-05-100:** 52.4	
	54-01-090: 35.8	**54-02-090:** 39.6	**54-03-090:** 43.3	**54-04-090:** 47.6	**54-05-090:** 51.9	
	54-01-080: 35.3	**54-02-070:** 39.1	**54-03-080:** 42.8	**54-04-080:** 47.1	**54-05-080:** 51.4	
	54-01-070: 34.7	**54-02-070:** 38.6	**54-03-070:** 42.3	**54-04-070:** 46.6	**54-05-070:** 50.9	**54-06-070:** 55.3
10+	**54-01-060:** 34.2	**54-02-060:** 38.1	**54-03-060:** 41.8	**54-04-060:** 46.1	**54-05-060:** 50.4	**54-06-060:** 54.7
	54-01-050: 33.7	**54-02-050:** 37.6	**54-03-050:** 41.3	**54-04-050:** 45.6	**54-05-050:** 49.9	**54-06-050:** 54.2
	54-01-040: 33.2	**54-02-040:** 37.1	**54-03-040:** 40.8	**54-04-040:** 45.1	**54-05-040:** 49.4	**54-06-040:** 53.7
	54-01-030: 32.7	**54-02-030:** 36.5	**54-03-030:** 40.3	**54-04-030:** 44.6	**54-05-030:** 48.9	**54-06-030:** 53.2
	54-01-020: 32.2	**54-02-020:** 36.0	**54-03-020:** 39.8	**54-04-020:** 44.1	**54-05-020:** 48.4	**54-06-020: 52.7**
	54-01-010: 31.6	**54-02-010:** 35.4	**54-03-010:** 39.1	**54-04-010:** 43.1	**54-05-010:** 47.8	**54-06-010:** 52.1
55	**55-01-100:** 36.3	**55-02-100:** 40.1	**55-03-100:** 43.8	**55-04-100:** 48.1	**55-05-100:** 52.4	**55-06-100:** 56.8
	55-01-090: 35.8	**55-02-090:** 39.6	**55-03-090:** 43.3	**55-04-090:** 47.6	**55-05-090:** 51.9	**55-06-090:** 56.3
	55-01-080: 35.3	**55-02-080:** 39.1	**55-03-080:** 42.8	**55-04-080:** 47.1	**55-05-080:** 51.4	**55-06-080:** 55.8
	55-01-070: 34.7	**55-02-070:** 38.6	**55-03-070:** 42.3	**55-04-070:** 46.6	**55-05-070:** 50.9	**55-06-070:** 55.3
10+	**55-01-060:** 34.2	**55-02-060:** 38.1	**55-03-060:** 41.8	**55-04-060:** 46.1	**55-05-060:** 50.4	**55-06-060:** 54.7
	55-01-050: 33.7	**55-02-050:** 37.6	**55-03-050:** 41.3	**55-04-050:** 45.6	**55-05-050:** 49.9	**55-06-050:** 54.2
	55-01-040: 33.2	**55-02-040:** 37.1	**55-03-040:** 40.8	**55-04-040:** 45.1	**55-05-040:** 49.4	**55-06-040:** 53.7
	55-01-030: 32.7	**55-02-030:** 36.5	**55-03-030:** 40.3	**55-04-030:** 44.6	**55-05-030:** 48.9	**55-06-030:** 53.2
	55-01-020: 32.2	**55-02-020:** 36.0	**55-03-020:** 39.8	**55-04-020:** 44.1	**55-05-020:** 48.4	**55-06-020:** 52.7
	55-01-010: 31.6	**55-02-010:** 35.4	**55-03-010:** 39.1	**55-04-010:** 43.5	**55-05-010:** 47.8	**55-06-010:** 52.1

56	**56-01-100:** 21.4	**56-02-100:** 24.7	**56-03-100:** 29.0	**56-04-100:** 33.8	**56-05-100:** 38.7	**56-06-100:** 43.0
	56-01-090: 20.9	**56-02-090:** 24.2	**56-03-090:** 28.5	**56-04-090:** 33.3	**56-05-090:** 38.2	**56-06-090:** 42.5
	56-01-080: 20.4	**56-02-080:** 23.7	**56-03-080:** 28.0	**56-04-080:** 32.8	**56-05-080:** 37.7	**56-06-080:** 42.0
	56-01-070: 19.9	**56-02-070:** 23.2	**56-03-070:** 27.5	**56-04-070:** 32.3	**56-05-070:** 37.2	**56-06-070:** 41.5
	56-01-060: 19.4	**56-02-060:** 22.7	**56-03-060:** 27.0	**56-04-060:** 31.8	**56-05-060:** 36.7	**56-06-060:** 41.0
	56-01-050: 18.9	**56-02-050:** 22.2	**56-03-050:** 26.5	**56-04-050:** 31.3	**56-05-050:** 36.2	**56-06-050:** 40.5
	56-01-040: 18.4	**56-02-040:** 21.7	**56-03-040:** 26.0	**56-04-040:** 30.8	**56-05-040:** 35.7	**56-06-040:** 40.0
	56-01-030: 17.9	**56-02-030:** 21.2	**56-03-030:** 25.5	**56-04-030:** 30.3	**56-05-030:** 35.2	**56-06-030:** 39.5
	56-01-020: 17.4	**56-02-010: 20.6**	**56-03-020:** 25.0	**56-04-020:** 29.8	**56-05-020:** 34.7	**56-06-020:** 39.0
	56-01-010: 16.8	**56-02-010:** 20.0	**56-03-010:** 24.3	**56-04-010:** 29.1	**56-05-010:** 34.0	**56-06-010:** 38.3

57	**57-01-100:** 21.4	**57-02-100:** 24.7	**57-03-100:** 29.0	**57-04-100:** 33.8	**57-05-100:** 38.7	**57-06-100:** 43.0
	57-01-090: 20.9	**57-02-090:** 24.2	**57-03-090:** 28.5	**57-04-090:** 33.3	**57-05-090:** 38.2	**57-06-090:** 42.5
	57-01-080: 20.4	**57-02-080:** 23.7	**57-03-080:** 28.0	**57-04-080:** 32.8	**57-05-080:** 37.7	**57-06-080:** 42.0
	57-01-070: 19.9	**57-02-070:** 23.2	**57-03-070:** 27.5	**57-04-070:** 32.3	**57-05-070:** 37.2	**57-06-070:** 41.5
	57-01-060: 19.4	**57-02-060:** 22.7	**57-03-060:** 27.0	**57-04-060:** 31.8	**57-05-060:** 36.7	**57-06-060:** 41.0
	57-01-050: 18.9	**57-02-050:** 22.2	**57-03-050:** 26.5	**57-04-050:** 31.3	**57-05-050:** 36.2	**57-06-050:** 40.5
	57-01-040: 18.4	**57-02-040:** 21.7	**57-03-040:** 26.0	**57-04-040:** 30.8	**57-05-040:** 35.7	**57-06-040:** 40.0
	57-01-030: 17.9	**57-02-030: 21.2**	**57-03-030:** 25.5	**57-04-030:** 30.3	**57-05-030:** 35.2	**57-06-030:** 39.5
	57-01-020: 17.4	**57-02-020:** 20.6	**57-03-020:** 25.0	**57-04-020:** 29.8	**57-05-020:** 34.7	**57-06-020:** 39.0
	57-01-010: 16.8	**57-02-010:** 20.0	**57-03-010:** 24.3	**57-04-010:** 29.1	**57-05-010:** 34.0	**57-06-010:** 38.3

58	**58-01-100:** 18.2	**58-02-100:** 21.9	**58-03-100:** 25.2	**58-04-100:** 30.1	**58-05-100:** 34.9	
	58-01-90: 17.7	**58-02-090:** 21.4	**58-03-090:** 24.7	**58-04-090:** 29.6	**58-05-090:** 34.4	
	58-01-80: 17.2	**58-02-080:** 20.9	**58-03-080:** 24.2	**58-04-080:** 29.1	**58-05-080:** 33.9	
	58-01-70: 16.7	**58-02-070:** 20.4	**58-03-070:** 23.7	**58-04-070:** 28.6	**58-05-070:** 33.4	**58-06-070: 37.7**
	58-01-60: 16.2	**58-02-060:** 19.9	**58-03-060:** 23.2	**58-04-060:** 28.1	**58-05-060:** 32.9	**58-06-060: 37.2**
	58-01-50: 15.7	**58-02-050:** 19.4	**58-03-050:** 22.7	**58-04-050:** 27.6	**58-05-050:** 32.4	**58-06-050:** 36.7
	58-01-40: 15.2	**58-02-040:** 18.9	**58-03-040:** 22.2	**58-04-040:** 27.1	**58-05-040:** 31.9	**58-06-040:** 36.2
	58-01-30: 14.7	**58-02-030:** 18.4	**58-03-030:** 21.7	**58-04-030:** 26.5	**58-05-030:** 31.4	**58-06-030:** 35.7
	58-01-20: 14.2	**58-02-020:** 17.9	**58-03-020:** 21.2	**58-04-020:** 26.0	**58-05-020:** 30.9	**58-06-020:** 35.2
	58-01-10: 13.5	**58-02-010:** 17.3	**58-03-010:** 20.5	**58-04-010:** 25.4	**58-05-010:** 30.2	**58-06-010:** 34.5

59	**59-01-100:** 18.2	**59-02-100:** 21.9	**59-03-100:** 25.2	**59-04-100:** 30.1	**59-05-100: 34.9**	
	59-01-090: 17.7	**59-02-090: 21.4**	**59-03-090:** 24.7	**59-04-090:** 29.6	**59-05-090:** 34.4	
	59-01-080: 17.2	**59-02-080:** 20.9	**59-03-080:** 24.2	**59-04-080:** 29.1	**59-05-080:** 33.9	
	59-01-070: 16.7	**59-02-070:** 20.4	**59-03-070:** 23.7	**59-04-070:** 28.6	**59-05-070:** 33.4	**59-06-070:** 37.7
	59-01-060: 16.2	**59-02-060:** 19.9	**59-03-060:** 23.2	**59-04-060:** 28.1	**59-05-060:** 32.9	**59-06-060:** 37.2
	59-01-050: 15.7	**59-02-050:** 19.4	**59-03-050:** 22.7	**59-04-050:** 27.6	**59-05-050:** 32.4	**59-06-050:** 36.7
	59-01-040: 15.2	**59-02-040:** 18.9	**59-03-040:** 22.2	**59-04-040:** 27.1	**59-05-040:** 31.9	**59-06-040:** 36.2
	59-01-030: 14.7	**59-02-030:** 18.4	**59-03-030:** 21.7	**59-04-030:** 26.5	**59-05-030:** 31.4	**59-06-030:** 35.7
	59-01-020: 14.2	**59-02-020:** 17.9	**59-03-020:** 21.2	**59-04-020:** 26.0	**59-05-020:** 30.9	**59-06-020:** 35.2
	59-01-010: 13.5	**59-02-010:** 17.3	**59-03-010:** 20.5	**59-04-010:** 25.4	**59-05-010:** 30.2	**59-06-010:** 34.5

60	**60-01-100: 21.4**	**60-02-100:** 24.7	**60-03-100:** 29.0	**60-04-100: 33.8**	**60-05-100:** 38.7	
	60-01-090: 20.9	**60-02-090:** 24.2	**60-03-090:** 28.5	**60-04-090:** 33.3	**60-05-090:** 38.2	

	60-01-080: 20.4	**60-02-080:** 23.7	**60-03-080:** 28.0	**60-04-080:** 32.8	**60-05-080:** 37.7	
	60-01-070: 19.9	**60-02-070:** 23.2	**60-03-070:** 27.5	**60-04-070:** 32.3	**60-05-070:** 37.2	**60-06-070:** 41.5
	60-01-060: 19.4	**60-02-060:** 22.7	**60-03-060:** 27.0	**60-04-060:** 31.8	**60-05-060:** 36.7	**60-06-060:** 41.0
	60-01-050: 18.9	**60-02-050:** 22.2	**60-03-050:** 26.5	**60-04-050:** 31.3	**60-05-050:** 36.2	**60-06-050:** 40.5
	60-01-040: 18.4	**60-02-040:** 21.7	**60-03-040:** 26.0	**60-04-040:** 30.8	**60-05-040:** 35.7	**60-06-040:** 40.0
	60-01-030: 17.9	**60-02-030:** 21.2	**60-03-030:** 25.5	**60-04-030:** 30.3	**60-05-030:** 35.2	**60-06-030:** 39.5
	60-01-020: 17.4	**60-02-020:** 20.6	**60-03-020:** 25.0	**60-04-020:** 29.8	**60-05-020:** 34.7	**60-06-020:** 39.0
	60-01-010: 16.8	**60-02-010:** 20.0	**60-03-010:** 24.3	**60-04-010:** 29.1	**60-05-010:** 34.0	**60-06-010:** 38.3
61	**61-01-100:** 21.4	**61-02-100: 24.7**	**61-03-100:** 29.0	**61-04-100:** 33.8	**61-05-100:** 38.7	**61-06-100:** 43.0
	61-01-090: 20.9	**61-02-090:** 24.2	**61-03-090:** 28.5	**61-04-090:** 33.3	**61-05-090:** 38.2	**61-06-090:** 42.5
	61-01-080: 20.4	**61-02-080:** 23.7	**61-03-080:** 28.0	**61-04-080:** 32.8	**61-05-080:** 37.7	**61-06-080:** 42.0
	61-01-070: 19.9	**61-02-070:** 23.2	**61-03-070:** 27.5	**61-04-070:** 32.3	**61-05-070:** 37.2	**61-06-070:** 41.5
	61-01-060: 19.4	**61-02-060:** 22.7	**61-03-060:** 27.0	**61-04-060:** 31.8	**61-05-060:** 36.7	**61-06-060:** 41.0
	61-01-050: 18.9	**61-02-050:** 22.2	**61-03-050:** 26.5	**61-04-050:** 31.3	**61-05-050:** 36.2	**61-06-050:** 40.5
	61-01-040: 18.4	**61-02-040:** 21.7	**61-03-040:** 26.0	**61-04-040:** 30.8	**61-05-040:** 35.7	**61-06-040:** 40.0
	61-01-030: 17.9	**61-02-030:** 21.2	**61-03-030:** 25.5	**61-04-030:** 30.3	**61-05-030:** 35.2	**61-06-030:** 39.5
	61-01-020: 17.4	**61-02-020:** 20.6	**61-03-020:** 25.0	**61-04-020:** 29.8	**61-05-020:** 34.7	**61-06-020:** 39.0
	61-01-010: 16.2	**61-02-010:** 20.0	**61-03-010:** 24.3	**61-04-010:** 29.1	**61-05-010:** 34.0	**61-06-010:** 38.3

Appendix 7

Customer number and item number is shown in separate colums. The help column shows information from both customer number and item number

CO number	Item number	Help
1234	ABC	ABC_1234
1234	ABC	ABC_1234
1234	ABC	ABC_1234
1234	DEF	DEF_1234
1234	GHI	GHI_1234
1234	GHI	GHI_1234
1234	JKL	JKL_1234
1234	JKL	JKL_1234
2345	DEF	DEF_2345
2345	GHI	GHI_2345
2345	GHI	GHI_2345
3456	ABC	ABC_3456
3456	ABC	ABC_3456
3456	ABC	ABC_3456
3456	DEF	DEF_3456
3456	DEF	DEF_3456
3456	JKL	JKL_3456
3456	JKL	JKL_3456
3456	JKL	JKL_3456
4567	ABC	ABC_4567
4567	ABC	ABC_4567
4567	ABC	ABC_4567
4567	GHI	GHI_4567
4567	GHI	GHI_4567
5678	ABC	ABC_5678
5678	ABC	ABC_5678
5678	ABC	ABC_5678
5678	DEF	DEF_5678
5678	DEF	DEF_5678
5678	GHI	GHI_5678
5678	GHI	GHI_5678
6789	ABC	ABC_6789
6789	ABC	ABC_6789
6789	ABC	ABC_6789
6789	GHI	GHI_6789
6789	GHI	GHI_6789
6789	GHI	GHI_6789
6789	JKL	JKL_6789
6789	JKL	JKL_6789
6789	JKL	JKL_6789

Appendix 8

The amount of how many times an item number occur on different customer order is shown. With other words, the picking frequency

CO number	Item number	Help duplicates removed
1234	ABC	ABC_1234
1234	GHI	GHI_1234
1234	DEF	DEF_1234
1234	JKL	JKL_1234
2345	DEF	DEF_2345
2345	GHI	GHI_2345
3456	ABC	ABC_3456
3456	DEF	DEF_3456
3456	JKL	JKL_3456
4567	ABC	ABC_4567
4567	GHI	GHI_4567
5678	ABC	ABC_5678
5678	DEF	DEF_5678
5678	GHI	GHI_5678
6789	ABC	ABC_6789
6789	GHI	GHI_6789
6789	JKL	JKL_6789

Item number	Amount
ABC	5
GHI	5
DEF	4
JKL	3

Appendix 9

Calculations on reduction of times

Beam	Current location	Distance (sec)	Picking frequency (pcs)	Total time per year (sec)	Total time per year (h)	Total distance per year (m)
ABCD	54-01-050	33,7	741	49943,4	13,87316667	69421,326
EFGH	59-01-050	15,7	647	20315,8	5,643277778	28238,9620
IJKL	55-01-040	33,2	639	42429,6	11,786	58977,144

Beam	Hot zone location	Hot zone distance (sec)		Total time hot zone per year (sec)	Total time hot zone per year (h)	Total distance hot zone per year (m)	Time reduction
ABCD	59-01-010	13,5		20007	5,5575	27809,73	0,6159753
EFGH	-						
IJKL	58-01-010	13,5		17253	4,7925	23981,67	0,5933735